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DEVELOPMENT OF A METHOD OF DETERMINING THE DEGREE OF CANADIAN CONTEXT IN SCIENCE INSTRUCTIONAL MATERIALS

by

©

RICHARD MONTEGUE MRAZEK

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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Date Aug. 26, 1982.

ABSTRACT

The study develops a theoretical perspective for a Canadian context for science education. On the basis of this perspective a set of criteria or a clue structure was determined which could be used to assess the extent to which instructional materials used in science teaching in Canada reflect a Canadian context. Development of the theoretical perspective and clue structure with appropriate validation was accomplished in five stages.

In Stage I an initial version of a theoretical perspective for a Canadian context in science education was developed based on an extensive search of the science, science education, education, and Canadian cultural literature. Stage II sought reaction to this initial theoretical perspective by a limited sample of 20 science educators and science graduate students at the University of Alberta. On the basis of this reaction and further literature research and informal analysis, a revised edition of the theoretical perspective was drafted in Stage III.

This led to Stage IV, the validation of the revised theoretical perspective by a national sample of 120 science educators, scientists and science teachers. Attempts were made to have a representative sample with regards to geographical distribution and distribution among individuals integrally involved or affiliated with science education in Canada. Forty-four validators responded providing reactions and comments to the theoretical perspective. A high level of support

was received for the theoretical perspective, however there was a great deal of controversy surrounding the issue of national identidy. The greatest support from the national validators was for inclusion of technology in science education, stressing the interrelationship of pure and applied science, inclusion of the science-society interaction, maximum use in science teaching of the local environment and applications of science to the students' immediate environment.

In Stage V a clue structure was derived from the theoretical perspective consisting of 15 elements for assessing science instructional materials for Canadian context. These elements were included in a questionnaire to be validated by 8 different science teacher groups, of which 4 were prospective science teachers and 4 were practicing teachers. The sample consisted of 128 teachers of which 85 responded.

Validation of the clue structure for a Canadian context in science education showed very strong support from teachers. Elements which included maximum use of the local environment in science teaching received the greatest support.

Factor analysis of the questionnaire responses determined that there were perceived relationships between the elements of the clue structure but they were not readily interpretable. Multivariate statistical analysis showed that there were significant differences in support of elements of the clue structure by science teachers representing different levels of teaching experience. Further application of multivariate statistical analysis also revealed that there were differences in perception by the different science teaching groups as to which elements should be included in a Canadian context for science education.

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CHAPTER I

Introduction

Most educators would agree that education does not and cannot take place in a cultural vacuum. It may be stated that

> "All teaching and learning has a geographical, a historical and a social context; it happens in a particular place, at a particular time, and it involves particular people. It makes use of a particular language, and it takes place against the background of a view of the world and of man's place in it characteristic of a particular society" (Wilson, 1981:vii).

It follows then, that teachers can make a direct impact on what students think through their practices and actions in classrooms. The context within which teaching takes place has a major influence on education. Therefore, teachers are engaged in curriculum building when they decide what to teach, how to teach it and how to order what is taught. If each activity in the classroom is the basic unit of a curriculum (Eisner, 1965), then consideration of the context in which a subject is taught is an important curriculum issue.

Unfortunately, some science teachers and educators have overlooked the importance of the context in which science is being taught, possibly due to a false notion that science education takes place in a totally objective and neutral environment.

Background and Justification for the Study

In Canada today, there is much discussion regarding the inclusion of a Canadian context for science education. This discussion has in part dealt with a concern over a perceived inadequate emphasis of Canadian context. More specifically, the concern has arisen from the inability of students to relate science knowledge to their own history, culture, and social and physical environment. Dubas and Martel (1973, 1975), Symons (1975), Suzuki (1977, 1980), Page (1979), and others have reached the conclusion that the manner in which science is taught or learned in Canada does not adequately reflect a Canadian context for science education.

The concern expressed is not necessarily to replace all science teaching with a Canadian context for science teaching. It is rather to recognize that there is also a context for science education which is described here as a Canadian context. Also, in order to provide students with as complete a view of science education as possible, we must not teach in one context to the exclusion of others. If a Canadian context for science education can be determined, then it should be given consideration in our schools, complementing other contexts already in use.

However, in all too many cases, changes in science curriculum and instruction have been based upon research and study conducted in the United States and to a lesser extent, in Britain. American studies in biology, in physics and in chemistry, including the textbooks and programmes which were produced in connection with them, have been applied extensively in Canada. Such modifications as have been made have been limited to relatively minor accommodations of local phenomena as noted by Crean (1976).

In June of 1972, the Commission on Canadian Studies was established by the Association of Universities and Colleges of Canada.

Professor T.H.B. Symons as chairman was asked to consider the state of teaching and research about Canada in Canadian universities. Symons included the question of whether or not teaching and research in the sciences were related appropriately to Canadian circumstances. Symons received representations from more than fifty scientific associations and some five hundred scientists personally made their views known (Page, 1979).

Following the publication of the first two volumes of the Report of the Commission on Canadian Studies in 1975, To Know Ourselves, Dr. Symons was invited on June 15-16, 1978 to address the members of the Science Council of Canada on the issues raised in the science and technology chapter of his report. As a result of that session, the Council commissioned a position paper on the implications of Dr. Symons' observations. To assist in this work, the Science Council sponsored a colloquium on October 24, 1978 entitled "A Conversation About Canadian Content in Science Education" (Page, 1981).

In A Canadian Context for Science Education, the Council's commissioned paper, James E. Page (1979) explored the issues and concerns for science educators that were raised by the participants at the 1978 Science Council of Canada colloquium. He identified the major areas of concern as:

(i) lack of attention to Canadian dimensions and problems in science teaching and research.

(ii) failure of Canadians to recognize that science and technology are integral parts of our society's culture.

Since our teachers are trained in our universities, there is no reason to suspect that the above two areas of concern expressed by Page, are any better in our elementary and secondary schools. Indeed, owing to the declining attention given to science in elementary programs which accompanied the revival of the 3 R's in our schools, the situation might probably be worse than that in the universities.

Page (1979) suggests that the most significant result of the Science Council's colloquium was a firm statement of those present that adequate recognition of a Canadian context for science education ought to be a basic educational objective. If Canadians understand the relationship between science and society and if they are able to comprehend Canadian science issues, then they will be able to deal more effectively with Canada's future. Page also suggested that the Council do a major study of the questions raised in the Symons Report and that on release of the Council's own study a major conference be held to consider the findings.

After establishing a Working Group on Science Education in 1979 the Science Council directed resources to an exploration of the science education issues raised in the Symons Report and its own deliberations (Page, 1981).

Hodgetts (1968) had suggested ten years earlier that students also needed the intellectual skills, the knowledge and the opportunities to play more effective and satisfying roles as citizens in the wider society of Canada. He further suggested that ensuring a Canadian context in our schools would enable elementary and secondary schools in Canada to play a much more inspiring role in Canadian affairs than they had in previous decades. A decade later, consideration is again being given to this area.

One of the methods for transmission of Canadian context in science education is through instructional materials. While only supportive to the curriculum and to teaching, textbooks and learning materials have a measurable impact on what students learn (Hodgetts and Gallagher, 1978).

As was noted by Crean (1976) only token recognition of the rich diversity of the Canadian experience is included in most instructional materials used in Canadian schools. Amid the flurry of discussions dealing with a Canadian context for science education (with focus on Canadian science content, Canadian science and society interaction and history of Canadian science and technology) there come suggestions for the creation of instructional materials to reflect this context.

This, however, is not such an easy task. Nay (1980) points out that before one embarks on preparation of curriculum materials for teaching science in a Canadian context, there is a need for a penetrating analysis of current science education policies, practices and needs in Canada, and in what way they are uniquely Canadian.

The question of Canadian context in science education becomes a question of status of knowledge. What knowledge is perceived as being important to teach in science education? Is this knowledge different in Canada than other parts of the world?

To answer what knowledge of science education is perceived as being important to teach in Canadian schools, one must take some direction from the goals and objectives set out by the provincial ministries of education in Canada. These must serve as initial signposts, since it is doubtful that all the power groups in Canadian society would agree upon the goals and purposes of science education. Fortunately, however, among the stated provincial goals and objectives for science education, there are a significant number relating to science-society interaction and even a few focusing on Canadian context. It is these specific goals and objectives that must constitute the basis of a discussion of a Canadian context for science education, especially in regard to curriculum decision making. To guide and facilitate this decision-making there is an urgent need for a method of identifying and analyzing science instructional materials for Canadian context.

Statement of the Problem

The methodological problem which this work addresses is:

> "How is it possible to determine the extent to which instructional materials used in science teaching in Canada reflect a Canadian context?"

In order to accomplish this, a theoretical perspective of Canadian context in science education was devised. This perspective was validated in two stages. A clue structure was derived from the final version of the perspective, consisting of elements which should be included in a Canadian context for science education. This clue structure can be used to identify and analyze science instructional materials for Canadian context. An attempt was made to validate the clue structure by transforming it into a questionnaire. This was administered to practicing and prospective science teachers.

The present study focuses on the following specific questions:

(1) What is an acceptable Canadian context for science education which will be relevant to students in their adult lives?

(2) What clue structure for Canadian context in science education will yield a meaningful assessment of science education programs?

(3) Will such a clue structure provide valid measures or descriptions of Canadian context?

(4) Is there support for the inclusion in science teaching of elements of Canadian context as given in the theoretical perspective and the clue structure?

The validation of the elements of the clue structure by means of the questionnaire may be expressed by means of the following null hypotheses:

Ho_1: There is no difference in support of elements to be included in a Canadian context for science education by prospective biology teachers, prospective physical science teachers, prospective elementary science teachers or prospective environmental education teachers.

Ho_2: There is no difference in perception by the four groups of prospective science teachers for inclusion of elements in a Canadian context as represented by the variables identified in factor analysis.

Ho_3: There is no difference in perception of elements to be included in a Canadian context for science education by prospective biology teachers and practicing senior high school biology teachers.

Ho_4: There is no difference in perception of elements to be included in a Canadian context for science education by prospective physical science teachers and practicing senior high school physical science teachers.

Ho_5: There is no difference in perception of elements to be included in a Canadian context for science education by prospective physical science teachers and practicing junior high physical science teachers.

Ho_6: There is no difference in perception of elements to be included in a Canadian context for science education by prospective biology teachers and practicing junior high school biology teachers.

Ho_7: There is no difference in perception of elements to be included in a Canadian context for science education by junior high school biology teachers, junior high school physical science teachers, senior high school biology teachers, and senior high school physical science teachers.

Definition of Terms

Canadian science "content"

This will refer to subject matter that actually includes reference to Canada (i.e., geographical location, Canadian discovery or invention, Canadian science history, etc.).

Canadian "context"

This will refer to all prevailing knowledge, beliefs, values, morals, customs, laws and other attributes which are specifically associated with individuals who inhabit the boundaries of Canada. This includes influences on those cultural components such as history, tradition, population mix, geography, science and technology, and the political and economic system.

Canadian science "context" in science education

Shall be taken to mean the influence of the Canadian environment (physical and social) on science and science education in Canada, and its presentation in science teaching in a manner which reflects those influences. This includes historical or contemporary circumstances of Canada which affect science education matters. Canadian context includes Canadian content as an integral component.

Canadian identity

This shall be taken to mean an identity consisting of common purposes, a common code of behavior and a common way of interpreting events. These have arisen from sharing the common physical and social environment known as Canada.

Clue structure

This will refer to a system as developed by Roberts and Russell (1975) of selected questions, analytical in nature, that when answered, will provide systematic and detailed information about science instructional materials.

Informal analysis

This refers to analysis as elaborated by Roberts and Russell (1975) that is oriented to general life concerned with values and concerned with systematic conceptualizations of the actual usage of terms employed to discuss important events in educational practice.

Relevance

This refers to the result of the selective and interpretive activity of the individual acting within and observing the reality which surrounds him. A major portion of the individual's structures of relevance originates outside his personal experience and exists in the social world of the group to which the person belongs.

Science

This refers to those areas of the school curriculum designated as science (e.g., physics, chemistry, biology, life sciences, earth and space sciences, physical sciences, etc.). This shall include those branches of study that relate to the phenomena of the material universe and their laws (known as pure science), as well as any practical art utilizing scientific knowledge (known as applied science or technology).

Science instructional materials

This refers to student and/or teacher resources explicitly designed to be used for teaching and learning in the science classroom.

Theoretical perspectives

This refers to conceptualizations which provide ways of viewing the complexity of educational phenomena in orderly and meaningful patterns.

Validation

This term is used in two different senses in this study. In the first sense it refers to the measure of the extent to which the theoretical perspective achieves agreement among the people solicited to give a reaction. In the second sense, validation refers to the perceived importance of elements in the clue structure. This involves allowing a science teaching body to rank these elements as to their perceived importance to a Canadian context for science education.

Values

This refers to any principle, proposition, policy, fact or idea which is the object of human interest and judgement. These are manifested in assertions about the nature of science, assertions about the value of technology, as well as ethical and moral judgements (e.g., environmental policies).

Delimitations

1. This study concerns itself only with one dimension of the Canadian 'milieu', namely, the Canadian context in science education.

2. In this study, the development of the theoretical perspective and the clue structure is based solely on a paradigm developed by Roberts and Russell (1975) as described in a following section.

3. This study represents only one approach to evaluation of science instructional materials for Canadian content and does not attempt to deal with other curriculum design elements.

4. Attention will be given to other areas of the curriculum only when these overlap directly with science teaching and learning.

5. The sample used in the initial limited group reaction to the theoretical perspective was restricted to graduate students and instructors in science education at the University of Alberta, Edmonton, during the 1981-82 session.

6. The national sample of scientists, science educators and science teachers used in validation of the theoretical perspective was a non-random one.

7. The sample of practicing and prospective science teachers was restricted to those taking part in secondary science practicum and curriculum and instruction courses at the University of Alberta, Edmonton, in the 1982 winter session.

Limitations

1. The Canadian context is only one of several for teaching science, and for meaningful and relevant science instruction needs to be integrated with other contexts.

2. The author's approach to teaching science in a Canadian context is not the only one possible. However, the method developed in this study must stand by itself for other systematic methods do

not appear to be available for assessing Canadian context in science instructional materials with which it can be compared.

3. The validation outcomes for the theoretical perspective and clue structure are relevant only to the selected sample of validators used.

4. The theoretical perspective formulated in this study and the clue structure based upon it will inevitably bias the analysis of science instructional materials for Canadian context.

CHAPTER II

Review of the Related Literature

Introduction

The literature in this review has been selected to provide background on the state of science education in Canada and to summarize the research findings and literature which identify the problems that exist in the domain of Canadian context for science education. The literature review is contained in two units, due to the inclusion of a theoretical perspective in Appendix III. A significant portion of the literature review had to be included in Appendix III to support the theoretical perspective. Wherever possible redundancy and needless restating of portions of the review was avoided.

The literature review presented in this chapter is discussed under the following topics: Goals and Objectives of Canadian Science Education, The Social Context of Science, A Perspective of Science Education in Canada, Problems in the Definition of Science, and Instruments for Analyzing Science Education Instructional Materials.

Included in Appendix III are discussions centering on review of related literature in all aspects of the perspective: The Search for a Canadian Identity, The Perceived Canadian Identity Crisis, Nationalism and Internationalism in Canadian Science, Identity Crisis in Canadian Science Education and A Canadian Context for Science Education.

Goals and Objectives of Canadian Science Education

The Analysis of Provincial (and Territorial) Policies for Science Curricula recently completed by the Science Council of Canada (1981) indicates a high degree of similarity existing among the programs of the 12 jurisdictions in terms of the aims and science content. These statements of goals for each of the jurisdictions reflect a social context for science education. We take cognizance with the need to address this social context but usually shortchange this context in classroom practice.

Orpwood and Souque (1981) list the following major objectives as those identified by the Council of Ministers of Education and Science Council of Canada to be included in the aims and objectives of science teaching in Canada today:

1. Understanding scientific facts, concepts, laws, etc.
2. Developing social skills (e.g., cooperation, communication, sense of responsibility).
3. Relating science to career opportunities.
4. Developing the skills of reading and understanding science-related materials.
5. Understanding the nature and process of technological or engineering activity.
6. Developing attitudes appropriate to scientific endeavour (e.g., curiosity, creativity, skepticism).
7. Understanding the history and philosophy of science.
8. Understanding the practical applications of science.
9. Developing skills and processes of investigation (e.g., observing, classifying, conducting experiments).
10. Understanding the relevance of science to the needs and interests of both men and women.
11. Relating scientific explanation to the student's conception of the world.

12. Understanding the way that scientific knowledge is developed.
13. Developing an awareness of the practice of science in Canada.
14. Understanding the role and significance of science in modern society.

One may note that there are objectives which dwell specifically with the social context of science and science education. A Canadian social context is mentioned directly in this list as well.

Need for a Social Context of Science Education

As the lag time between a new scientific theory and its technical application is shortening, science teachers are pressed to respond to rapidly shifting instructional priorities. For decades the need has been expressed for citizens informed of the impact, procedures and limitations of the scientific and technological enterprise with these aspects being included in the general education of what may be described as the typical nonscience oriented person (Doran, 1980). Yet, Ste.-Marie (1982) notes that even though we live in a world in which our comfort, health and economy are dependent on science and technology, even though we are confronted every day by an environment that is influenced totally by the application of science, and even if science teachers are convinced of the importance of science in society, science education, with its curricula, textbooks and methodologies, has not succeeded in making students aware of the human and social impacts of science.

Even more important, Ste.-Marie (1982) suggests that the study of the sciences not only does not elicit from students an attitude favourable to the nature and purposes of science, but actually discourages potential candidates from a scientific career since science, in their eyes, has lost its intellectual and social prestige.

This criticism is carried one step further by Desautels (1982) who insists that Canadian science education

> "By arranging curriculum content strictly according to logic and discipline, with no reference whatever to the history of science, apart from parenthetical anecdotes, it ensures that students do not absorb a critical view of knowledge. By divorcing curriculum content from everyday or cultural reality, the knowledge acquired is rendered useless for the individual in his or her daily actions. By disassociating science and technology, the framework is already prepared for the division of labour. By carefully avoiding the integration of the social problems related to scientific and technical development, generations of young people are prepared for a passive, naive acceptance of what passes for progress. One can perhaps summarize this by saying that science teaching has fulfilled the role assigned to it of preparing an elite according to the requirements of the university to the detriment of acquiring a true scientific culture by the majority" (Desautels, 1982:).

Such criticism may seem extremely severe, yet, it is also becoming increasingly common. Donald George (1981) expresses concern that science education in Canada has had a preoccupation on the discipline of science as the discovery and validation of knowledge rather than engineering which is the application of knowledge towards the solution of real problems. He notes that science education has become more specialized, accompanied by dropping proportions of students studying science and declining public support for science. Much of this is due to the fact that the benefits of science and technology have become less self-evident. This is supported by Stronck (1980) who suggests the link between science and technology is generally being ignored in our schools and statistics imply that we need major stress on teaching about technology. This inclusion of technological activities in school science is further supported by Harrison and Dutton (1977) and Woolnough (1975).

There is, it seems, a very strong push for the inclusion of science in a social context through various methods, such as the inclusion of technology in science education. A possible reason for this is noted by Donald George (1981) who suggests that today's science textbooks the applications, if mentioned, related to experimental measurements or new phenomena, rather than real examples of the application of the principles of physical sciences outside the physical sciences themselves. The science student is, therefore, not given the opportunity to understand the use of science in the practical world. It may be suggested that though this is fine for the scientist or students aspiring to be scientists, it does very little for the majority of students in Canadian schools.

The responsibilities of our science educational system go beyond preparing students for careers in scientific or technological areas. The contribution of science and technology to the prosperity of a nation rests on two bases. One is the competence of the practitioners--the scientists and the engineers. The second, equally important base, consists of the overwhelming portion of the population who have no direct involvement in science and technology but influence the sources of funding and policy decisions for scientific and technological endeavors. If this group does not have some knowledge of science, then many important decisions at a national level dealing with science and technology will be made on the basis of ignorance and misunderstanding (National Science Foundation, 1980). Unfortunately, as Ste.-Marie (1982) points out, science teaching in most cases aims to impart a scientific culture to all students, whether they be future scientists or not and those who have no intention of going into a scientific career are treated the same as those who are planning to continue in science as a vocation. Ste-Marie also suggests that among students other than those already science-oriented, the role of science in society has dropped in prestige and respect and the study of science has suffered from a loss of interest; as well, programs designed specifically for students who were not science-oriented have been no more successful than traditional ones. Wilson (1981) adds that the popular view that pupils' attitudes to a school subject are determined by the intrinsic appeal of that subject is disproved by the simple observation that the popularity of a subject may change markedly in a relatively short space of time which is dramatically illustrated by the 'swing from science' in schools.

An example of the failure of even supposedly "special" programs failing is the Harvard Project Physics program which was developed to provide a general physics education to students who were not science oriented. Ste.-Marie (1982) indicates that even this program was not able to get through to non-science oriented students with lack of interest accompanied by a drop in performance by the students.

A feminist argument for change in direction in science is also being currently promoted. Speaking to the problem of the role of women in science, Janet Ferguson (1982) noted that science curricula and materials must stress the relevance and applications of the science content to everyday life in order to provide interesting scientific experiences which help girls to feel comfortable and confident in these activities. As has already been stated, the same should apply for all students in science education.

The perceived lack of relevance of science education in our schools is having a disastrous effect at all levels of schooling, not only the secondary one. The National Science Foundation (1980) confirms that the focus on basics in schools is having a negative impact on science teaching, particularly in the elementary grades. They suggest that what little attention science had been given in the elementary grades is diminishing because science is not viewed as "basic" by the general population or some educators. Even at the university and research level in science, there is an attempt to stress the science and society interaction. Davidson (1982) suggests that the Ministry of State for Science and Technology (MOSST) has recognized the fact that social assessment of technology must become a critical element of the technology process. In outlining the discussion paper entitled "Towards a Human Science Policy Framework", Davidson contends that one of the major objectives of the draft discussion paper is to convince the federal "scientific bureaucracy" to extend its science policy approach to the human sciences. This is reflected by a need to adopt what he refers to as a more integrated approach to scientific research and development which would use human science resources in an attempt to foresee and mitigate some of the social repercussions of particular technological advancements and to bound some of the social parameters of technological change (Davidson, 1982:9).

There has been a serious attempt to investigate the relationships between science and society. Holton (1973) has carried out several case studies to show that

> "the cultural connection between science and society today is not always as different from that of Newton's, or even Plato's, time as we have been led to believe. There is in practice a continual cultural exchange between science and the wider society. Interpretative resources enter science mainly through informal thinking, usually with only a very limited awareness of their external origins on the part of participants. They are refined and modified in the course of informal negotiation; and they are allowed into the public annals of science only after appropriate reformulation. These interpretative resources are not generated by the 'facts of nature', nor by the social life of a segregated research community alone. They must be understood at least in part as products of the social processes of society at large" (Mulkay, 1979:99).

Economic pressures have always played a substantial role in the development of theoretical science and in its applications in technology. As well, economics and education continuously interact. The content and methods of science education should then reflect these relationships (Wilson, 1981). Science education should, therefore, be integrally involved in the discussion of a societal context for teaching science.

Bybee (1977) and Uzzell (1978) have suggested that aims in science teaching have reflected changing social and educational situations and that science education will continue to change in response to new societal needs. Hurd (1969) reminds us though, that prior to the 1970's most school science totally ignored the social aspects of science. It would seem that the major focus of science education is being redirected by the needs of society. Bybee (1977), Elkana (1979) and Holmes (1977) help show that the extent of the effects of societal pressures on science education are much more powerful than had earlier been recognized.

We must also consider that students have socially-determined views on whatever topic is presented and must be helped to understand their science in its cultural context (Elkana, 1979). This suggests that social responsibility should be a possible aim of science education, a view also shared by many and superbly presented by Wilson.

> "The traditional view is that, while the inculcation of social responsibility in the pupil is an important aim of school education, the appropriate vehicle for it is the teaching of religion and the humanities, rather than the science lesson. However, many recent writers would disagree. Science can no longer be seen as a purely technical matter, the theories and practices of which are independent of the people who practise it and of the needs of the society in

> which it exists. If science education is truly to represent science to the learner, then the development of an awareness of the social implications of science must be among its aims. Based on such awareness, science education can be a powerful means of developing socially responsible attitudes" (Wilson, 1981:86).

A Perspective of Science Education in Canada

Holmes (1977) asserts that systems of science education have their own nation-specific features which include national attitudes to politics, economics, religion, and social class. All of these affect the nature of science curricula in schools. Holmes claims that the history of science education internationally over the past twenty years is the story of the tensions resultant from uncritical transfer of British or American science education programmes to other cultural contexts (Wilson, 1981).

If one accepts Wilson's (1981) view that the social characteristics of a national or ethnic group are essentially inseparable from its political organization, its economic structures and circumstances, its language and its predominant world view, then we must recognize the need to consider culture as a component of a science-Canadian society context. Taking a sociological definition of culture, where it is a system of references characterized by the values, standards, ideologies, myths, life-styles, and ways of thinking peculiar to a given society it is then from these elements that members of this society draw their motivations and aspirations, their individual and collective models of behavior (Lavoie-Roux, 1981). In this system, Lavoie-Roux (1981) defines the role played by education, and especially the school system as functioning to improve social relations and integrate young people into society.

We must, however, go beyond this first definition of culture to yet another perspective of culture referred to by Lavoie-Roux (1981) as the "intellectual" dimension. Lavoie-Roux (1981) uses sociologist Guy Rocher's definition of this intellectual dimension as "a mental relationship which man maintains with himself and with his entire milieu through the intermediary of various symbols (concepts, words, numbers, gestures, etc.) and through a constant effort to reflect and meditate on the realities and what they represent (page 75)".

As supported by Lavoie-Roux (1981) it is the relationship between science education and this cultural dimension that allows us to focus on the range of science knowledge and skills transmitted by schools. From this, one can see that culture cannot be viewed as entirely static. Garfinkle (1973) put forward the view that culture is man's accomodative milieu. Stephan (1981) contends that it would be misleading to speak of the culture of ethnic groups as if they existed apart from and independent of Canadian mainstream culture. He continues, following Garfinkle's reasoning, that "the very existence of the various groups within the boundaries of Canada's material and non-material environment as their 'accommodative milieu' entails the notion that inherited beliefs and customs, have to be tested daily against the realities of life within Canadian society" (1981:9).

It is no wonder then that Osborne (1982) suggests that one reason why many Canadian curriculum theorists have nothing to say about the direction of curricula in Canada is that they themselves do not know enough about the country, lacking training in history, the humanities, or the social sciences. He adds that this is a possible explanation of why someone like Northrop Frye has more interesting things to say about education than do many educationists.

A discussion of Canadian culture eventually leads to one of national identity. Goble (1981) presses home the view that Canada must recognize its national identity since "a nation working its way towards unity must do so through discovery of a national cultural identity; and to do so it needs a school system which will take and confirm and develop and codify and transmit whatever clues emerge as to the essence of the national cultural identity, and the nature of the common goals that will eventually clarify it" (page 66).

In support of the Organization for Economic Co-operation and Development (1976) claim that the search for a Canadian identity will not be fruitful if it is not grounded in education, Goble (1981) claims that "it does seem to be time that the national interest in education were recognized as legitimate and approached with openness, with honesty, and with the degree of rationality that might rescue the problem from the excessive provincialism in which it is at present mired" (page 71).

Even if we put aside the matter of cultural and national identity, we must still recognize the fact as does Goble (1981) that Canada exists as a state, with an elected legislature and a government that has clear responsibilities to its citizens; of which education, and more specifically science education, is one. This national responsibility has been the subject of much debate and spurned by many in science education. Yet, Osborne (1982) draws attention to a particularly pressing need to attend to the uniquely Canadian setting of the educational enterprise. He refers to the Science Council of Canada's attention to the Canadian themes found in the "objective" discipline of science, stressing the importance of seeing education in a Canadian context, as definitely not advocacy of educational chauvinism or "curriculum in one country". Osborne does note that there is "a conspicuous lack of attention being paid to the meaning of curriculum theory in a Canadian context" (1982:p. 95). One cannot avoid considering a Canadian national or cultural influence when discussing science curricula or science education. Mallea (1981) supports this view, stating

> "The school curriculum may therefore be said to represent a capsulized version of the culture a society believes is important to impart. In modern multi-ethnic societies, moreover, and this is particularly true of Canada, ethnocultural groups experience a great many things in common. Thus the urban, technological, and secular characteristics of the larger society have a considerable and highly dynamic impact on their life-styles, values, and institutions. Each group participates in the larger society, and even the most segregated or isolated group is affected by its centripetal tendencies" (page 98).

As an education system evolves slowly, there is time for aims of education to reflect the changing nature and expectations of society (Uzzell, 1978). In Canada, the education system has evolved rapidly, with conflicting expectations and aims resulting. The balance of cultural pressures on syllabuses will vary with the degree of centralization of a school system. In highly centralized systems political and economic criteria will dominate while in a decentralized system, social concerns will play a larger role (Wilson, 1981). As one can imagine, while Canada is caught between the two systems, we must recognize the many influences on the direction of science education in Canada. As well, one must keep in mind that in general terms, the priority accorded to school science education in a particular society reflects that given to science itself therefore its support is dependent on political will as a necessary, though not always sufficient, condition (Wilson, 1981). Orpwood (1980) suggests that what is at issue now for science education in Canada is not that students are not learning what science is or enough science but they do not appreciate the personal, social or national relevance of science. Apple (1970) would include the national relevance in the interaction of the number of systems of relevance which constitute the student's environment. Normally we focus on sets of relevances, those of the teacher of the student and the instructional material. If one considers Apple's (1979) view to be important to remember that schools do not merely "teach knowledge", but also "teach children" then it is necessary to consider what knowledge we select to teach children. Science education must be presented in a manner which reflects its related socio-economic context since the knowledge that is selected for use in schools--the legitimate principles, ideas, and categories--grows out of particular history and economic and political reality (Apple, 1979).

There have been many problems defining exactly how science education and particularly science is related to Canadian history. In other words, what makes it Canadian? Christian de Bresson (1982) suggests that every society evolves its own technology, embodied in tools and skills and that Canada through its investment choices has evolved its technology even if only through adaptation necessitated by specific local conditions. In defining what could be termed Canadian innovation de Bresson states

> "A Canadian innovation was defined as the first production of a product in Canada or the first use of a process in Canada for the purposes of commercial production. For example, harvesting machinery in Scandinavia for first use in Canada qualified as a 'Canadian innovation' according to our definition, alongside the first commercial use in the world of heavy water nuclear power generation (an imported scientific knowhow). Even the production in Canada, of a piece of machinery only used abroad qualified as a 'Canadian innovation'" (1982:p. 13).

When describing Canadian content in the wired world of computers, the Science Council of Canada Committee on Computers and Communication stated that "It is the courseware that will make it Canadian, because the hardware is going to look pretty much the same all over the world" (1981:37). As one can see, the particular aspect of science or science education may change which is referred to as specifically Canadian. However, it should also be recognized that there is an aspect that is Canadian. If students are to express themselves creatively in terms of what they learn from studying science or be able to make individual choices in confronting the human dilemma, then a passive, subject-centered curriculum is to be frowned upon (Ediger, 1982). To ensure that students can relate their science experiences to their own life-world, a Canadian context for science education should be used with other existing contexts of science.

Problems in the Definition of Science

In defining science, one encounters a dilemma. For some, the definition should describe the accepted meaning of science already in use. Given the many different contexts in which the word science is used, it is also necessary to assign or stipulate a special meaning for the word science. Until very recently, most have been content to accept the definition of science which generates a very narrow meaning. This is exemplified by Webster's (Gove, 1968) definition of science as

> ". . . Any branch or department of systematized knowledge considered as a distinct field of investigation or object of study; as, biology is a science; the science of astronomy or of mind. . . . A branch of learning; a science; esp. a science such as grammar, logic, or mathematics . . . A branch of study which is concerned with observation and classification of facts, esp. with the establishment (and, strictly, the quantitative formulation) of verifiable general laws, chiefly by induction and hypothesis; as, the biological, historical, and mathematical sciences."

Science is restricted to a narrow definition by the Oxford (1914) dictionary as well:

> ". . . In modern usage, often treated as synonymous with 'Natural and Physical Science', and thus restricted to those branches of study that relate to the phenomena of the material universe and their laws, sometimes with implied exclusion of pure mathematics."

For some science has not changed its accepted meaning in the last fifty years and is still capably presented by Durkheim's (1938) interpretation of representing phenomena not in terms of culturally contingent ideas but strictly in terms of their inherent properties with conclusions of the sciences being derived from facts (Durkheim, 1938). This is demonstrated in Munby's (1982) proposed purpose of science which is to construct generalized models to explain and predict natural phenomena where the constructions match data consistently.

This may be explained by the way that

> "Belief in the inherent stability and uniformity of the physical world has often been linked to a particular view of the relationship between fact and theory in science. From this orthodox position it is assumed that certain objects and processes exist in the physical world, that certain events occur consistently and that certain stable relationships persist: these objects, processes, events and relationships constitute the facts which science has to describe accurately and explain convincingly . . . These facts are seen as being theoretically neutral. They can, therefore, be expressed in a language which is independent of theory and formulated in a way which simply represents the observable realities of the physical world. Once firmly established, facts remain unaffected by interpretative advances. Indeed, as long as there have been no observational errors, they can undergo no change of content or meaning and they can be used, therefore, to discriminate objectively between theoretical alternatives (Mulkay, 1979:29)."

Now, another view has been expressed that the physical as well as the social world depends on shared meanings, and suggests that there is difficulty translating from one network of meanings to another and of achieving a common understanding of what is to count as "empirical material" (Mulkay, 1979). It is this dependence on empirical evidence which distinguishes the empirical sciences from the nonempirical disciplines of logic and pure mathematics, whose propositions are proved without essential reference to empirical findings. It also allows for the empirical sciences to be divided into the natural sciences which include physics, chemistry, biology and their border areas; and social sciences comprised of sociology, political science, anthropology, economics, historiography, and related disciplines (Hemsel, 1966).

One of the border areas which has been suggested for inclusion into the definition of natural sciences, much to the consternation of some, is technology. Technology is defined by Webster (Gove, 1968) as:

> "Industrial science, the science or systematic knowledge of the industrial arts, esp. of the more important manufactures as spinning, weaving, metallurgy, etc. . . Any practical art utilizing scientific knowledge, as horticulture or medicine; applied science contrasted with pure science."

A supporter for the inclusion of technology as a border area of science, George (1981), protests that young students are taught physics, chemistry, and biology as abstract, self-significant sciences which understandably come to represent the whole of science in their minds. He suggests this impression is reinforced later in their schooling when these branches of science become compartmentalized into clearly distinct courses taught by specialists. This impression is reinforced by Smith (1980) who observes that current textbooks in Canadian science classrooms have tended to emphasize the structure of the discipline, in-depth learning, and laboratory activities requiring considerable thought and insight. He considers that to students who are looking for "relevance," fulfillment of immediate objectives, job-related learnings, and practical applications of science to technology, the new science curricula have little appeal.

Another problem resulting from a limited view of science is how are we to deal with the current knowledge explosion in science? If we are concerned with conveying "factual" knowledge, science students will indeed be overwhelmed. This is demonstrated by the statistics revealed by Munby which include:

(1) "The total number of documents cited in Chemical Abstracts grew from 239,687 in 1967 to 306,906 in 1980;"

(2) "In 1927, Biological Abstracts cited 14,506 documents; the estimate for 1980 was 162,500;"

(3) "The subject of "Quantum Mechanics" in Chemical Abstracts, which elicited 634 papers in 1967, had burgeoned to an estimated 1180 papers in 1980;"

(4) "There are between 8 to 10 million pages of printed matter on science and technology topics added annually to our collected stock, according to a member of the USSR Academy of Sciences" (Munby, 1982:10).

In order to meet the many demands being placed on science education in Canada, and indeed throughout the world, it is necessary for us to rethink our traditional definitions of science as used in science education. An example of such a rethinking to include practical and theoretical is the definition of science given by Bronowski where science is the

> "organization of our knowledge in such a way that is commands more of the hidden potential in nature. What I have in mind therefore is both deep and matter of fact; it reaches from the kinetic theory of gases to the telephone and the suspension bridge and medicated toothpaste. It admits no sharp boundary between knowledge and use" (1965:7).

One factor which allows us to broaden the previously narrow view of science, is the increasingly accepted view that scientific knowledge is not totally stable in meaning nor independent of social context. It has also been implied that the content of established scientific knowledge should be treated to a considerable extent as the outcome of specifiable social processes (Mulkay, 1979).

An example of the social context involved in one particular area of science is the research done by scientists. Mitroff (1974) has concluded from his studies that the norm of emotional neutrality is countered by a norm of emotional commitment.

> "Scientists frequently regard it as perfectly acceptable to judge knowledge-claims on the basis of personal criteria. Instead of subjecting all research reports in their topic area to impersonal scrutiny, scientists regularly select out of the literature the findings of those colleagues whose work, for one reason or another, they have come to regard as reliable. In other words, scientists often regard it as proper to judge the man rather than the knowledge-claim" (Mitroff in Mulkay, 1979:67).

This is further reinforced by Mulkay (1979) who suggests the conclusions of every particular intellectual community will be constrained at least partly by such factors as their cultural resources, the structure of their social group and their place in the wider society. As well, he suggests that the scientist is able to use specialized knowledge to furnish an apparent technical rationale for policies which express his own social interests as well as the interests of other groups on whose behalf he is acting. Mulkay illustrates this through the following example:

> "One social context through which almost all significant scientific knowledge-claims pass is that of evaluation on behalf of a professional journal. But publication in a journal in no way establishes that a claim has been accepted by the scientific community. The assessment carried out at this juncture is relatively routine. Seldom is any attempt made to reproduce experimental data; and complex arguments are not usually examined in great detail. In short, the knowledge-claim is subject at this stage to a fairly superficial and preliminary appraisal of adequacy, consistency and significance" (Mulkay, 1979:57).

Problems originating from our changing definitions of science, with strong implications of social interaction, are further complicated in science education by our attitudes towards curriculum research in science education. Our notion that curriculum research is a "neutral scientific activity" allows us to find more ways of making the concrete individual student into an abstraction, and simultaneously divorcing the individual student from larger social movements which might give meaning to individual wants and needs (Apple, 1979). As we make progress in one area, we reify students in another. Attention must then be directed to our definition and attitudes toward science as well as addressing the issue of science education in order to understand what is to be included in a Canadian context for science education.

Instruments for Analyzing Science Education Instructional Materials

In order to have an awareness of the ideological and epistemological commitments educators must accept and make science education knowledge problematic and pay much greater attention to where the knowledge comes from and whose knowledge it is (Apple, 1979). We must also realize that the teacher is the single most important factor in effective curriculum development (Wilson, 1981). "Recent studies confirm the conclusion that classroom teachers play a pivotal role in the education of students. While teachers do not bear total responsibility, they do have a great deal of freedom and discretion in determining what the content of their courses will be" (National Science Foundation, 1980:49).

It is, therefore, essential to recognize that teachers, if provided with the proper tools, may ensure that the values integral to the aims and goals of science education in Canada are achieved in their science teaching and be made aware of the values which may be integral in the science instructional materials they use.

Factor and Kooser (1981) point out that it is intrinsic to the nature of education to produce changes in attitude which include values and that it is acceptable for teachers and authors to use materials of textbooks to present opinions, issues, facts, and policies whose ultimate effect is to change student attitude about science in a free society. The question posed is how such values should be argued, defended or criticised. Factor and Kooser (1981) suggest that

> "if there is a central cluster of values in science pedagogy, and if these are shaped and preserved by the standardization process as well as the author's preference and expertise, then those values ought to be stated in a context or form which is different from, but not incompatible with, the ways in which basic facts and fundamental skills are stated" (page 45).

Values, as Factor and Kosser (1981) use the term, would include any principle, proposition, policy, fact or idea which is the object of human interest including assertions about the nature of scientific method, assertions about the costs and benefits of a particular technology, specific historical episodes, as well as specific ethical principles or moral prescriptions.

As a result of this, teachers using science curriculum materials developed outside of the school system in which they are a part, have a responsibility to choose those that best suit their needs. The task of choosing from among several alternatives, or the decision to adopt a given set of materials, involves weighing simultaneously many different factors, both theoretical and practical (Mahung, 1980). Werner (1978) also suggests that it is necessary to evaluate the program, including the instructional materials, from a critical interpretation:

> "Program perspectives are shaped within larger political, geographical, and social contexts of educators. Their outlooks are not only associated with, but also serve, the interests of various groups (e.g., class, occupational, political, religious). Because educators are members of these groups, there is little neutrality in teaching, developing, or evaluating programs. Bias is inevitable because group members specify goals, select materials, and define activities. These tasks cannot be accomplished with a blank mind, without prior suppositions and beliefs, with an interest free stance, or with empty anticipations. Inevitably, these perspectives are shaped by former experiences within social and geographical locations, and political affiliations. Because everyone brings a viewpoint to the tasks at hand, and because this perspective serves as a basis for thinking and acting, the evaluator needs to examine the foundations of a program" (Werner, 1978:18).

There is a growing body of literature consisting of evaluation instruments or systems of analysis for examining curriculum materials for various features. Some of these are an "Instrument for Assessing Instructional Materials" (Eash, 1971-1972); "Curriculum Materials Analysis System" (Knight et al., 1971); "A Curriculum Materials Analysis System for Science" (Haussler and Pitman, 1973); and "Recommendations for Curriculum and Instructional Materials" (Tyler, Klein, et al., 1976).

Mahung (1980) points out the limitation common to these studies that the system of analysis used often fails to detect the more subtle implicit features. Tyler argues that "effective educational research is commonly guided by and requires the selection or formulation of conceptualizations which provide ways of viewing the complexity of educational phenomena in orderly and meaningful patterns (1967b, p. 56). As well, Tyler suggests that current research in science education "is not guided by, nor does it produce an adequate map of the factors and processes in science education" (1967a, p. 50).

Seemingly in answer to Tyler's dilemma, a very detailed and comprehensive instrument for analysis of instructional materials has been developed by the Education Products Information Exchange Institute - E.P.I.E. (1977) which actually parallels the classical curriculum development model of Ralph Tyler. The E.P.I.E. model for learning resources selection is a systematic multi-staged design which is characterized by an increased emphasis on instructional design analysis as a basis for evaluation and by its use of a standard language and framework.

The E.P.I.E. format does an excellent job of analyzing instructional materials from within its format and in its four instructional design constructs or elements. The evaluator, using the format, is required simply to check for the inclusion or exclusion of various items, according to an established criteria. However, the E.P.I.E. analysis is time consuming and subsequently teachers seem somewhat hesitant to use it extensively. E.P.I.E. does not include reference to those values which refer to a Canadian context, but it does provide an interesting structure for reference.

Due to the nature of the instrument required to serve as a clue structure for a Canadian context for science education, the curriculum materials evaluation were, at some later stage, directed toward examining the materials for "explicit" and "implicit" inherent features (as defined by Mahung, 1980) rather than assessing instructional outcomes. Explicit features include qualities or attributes of a set of materials such as the subject matter "content" covered and the stated objectives and aims of the materials. These features are accessible through a relatively cursory examination of the materials. Implicit features are not readily determined by cursory examination of the materials. These features require more in-depth and sophisticated analysis. Included in implicit features are views of the nature of the subject matter, the learner, the teacher and the milieu (social context). These are also known as Schwab's grounds for curriculum decision or four clusters of "curriculum determinants" (1962).

The instrument that is developed in the present study is based on the research paradigm proposed by Roberts and Russell (1975).

In the first step of their process, systematic theoretical perspectives for understanding issues important to science education in a significant way emerge from informal analysis. The sources are from informal analysis in the philosophy of science; epistemology; metaphysics; and informal analysis of a variety of educational concepts, particularly the concept teaching.

In order to translate a theoretical perspective to the context of science education, the development of a "clue structure" which is basically a scheme for analysis is required.

Once appropriate material has been identified, the next step then is the development of a clue structure for making the identified theoretical perspective applicable to the phenomena to be studied.

The final step (a point for possible further study) involves carrying the analysis through to completion. In the course of repeated application, i.e., to instructional materials, the clue structure is refined to improve its capability to match and account for actual science education phenomena.

An example of the application of the Roberts and Russell paradigm is provided by Kilbourn (1971). He drew upon theoretical perspectives developed by Scheffler, Schwab and Connelly to develop a clue structure for examining knowledge claims in science textbooks. His clue structure consisted of five questions, each one dealing with an aspect of the epistemology of material intended for student readers. The clue structure was then applied in a detailed examination of a portion of the BSCS Blue Version textbook, Biological Science: Molecules to man (Biological Sciences Curriculum Study, 1963). The result was that Kilbourn's clue structure assists one to understand why students must read between the lines of textbooks in order to understand the knowledge claims they are expected to master.

Munby (1969) and Russell (1973) provide further examples of the application of the Roberts and Russell paradigm.

Munby (1969) used Scheffler's (1965) theoretical perspective based upon informal analysis of three models of teaching to develop a clue structure by which to distinguish among these models in science lesson transcriptions. His clue structure consisted of a series of identifying features for each model translated into the specific context of science education. From his detailed analysis of two science lesson transcriptions, he demonstrated the use of the clue structure to distinguish between the impression model, insight model, and the rule model among approaches to teaching.

Russell (1973) explored the use of argument and authority in science teaching using informal analysis established by Komesar, Green, Peters, and Toulmin. Prusso (1972) developed a clue structure for identifying and classifying epistemological features of science classroom discourse called Profile and Epistemological Analysis.

CHAPTER III

Procedure and Design for the Study

Introduction

In this chapter, the design of the study is discussed in five steps or stages which together formed the framework for developing and validating a theoretical perspective and clue structure. The design of each of the five stages is described in some detail. Where appropriate, justifications of the methodology employed is included.

The first four of the five stages of the study were concerned with the development and validation of a theoretical perspective for a Canadian context for science education. The fifth stage was concerned with isolation of the elements of a clue structure from the theoretical perspective and validation of the clue structure by a group of science teachers.

STAGE I: Development of the Initial Draft of the Theoretical Perspective

In this stage, a theoretical perspective for a Canadian context for science education was developed on the basis of an extensive search of the science and science education literature. This involved informal analysis of the philosophy of Canadian science, nature of scientific knowledge, as well as Canadian conceptions of scientific inquiry and Canadian scientific discovery. In order to identify unique aspects of attitudes toward Canadian science activities, it was necessary to look in depth at the history of science in Canada and the development of science education in Canada.

The search for a theoretical perspective was guided by two considerations. First, as noted by Roberts and Russell (1975:115) and Mahung (1980:108), the work has to be relevant to the concerns of the study. Second, there exist various positions and views as to the definition of Canadian context for science education, and it was essential for the significance of the study to identify a view that was philosophically acceptable to science educators and teachers.

The outline of the Stage I version of "A Theoretical Perspective for A Canadian Context for Science Education" is included in Appendix I. Unfortunately, owing to its length, it was impossible to append the entire Stage I version of the theoretical perspective.

The Theoretical Perspective and Informal Analysis

In choosing an approach to challenging the problem of identifying what a Canadian context for science education is and what conceptions this brings to mind, it was necessary to seek a method which goes well beyond superficial empirical relationships. It was this necessity to be able to view complex science and science education phenomena and be able to identify factors and processes which led to the use in this study of the theoretical perspective and informal analysis.

Tyler's (1972) recommendations for the improvement of theory in science education rested on what is called theoretical perspectives which were conceptualizations which provide ways of viewing the complexity of educational phenomena in orderly and meaningful patterns and an adequate map of the factors and processes in science education. One reason for such importance being placed on development of theoretical perspectives is outlined by Shulman:

> "One important characteristic of much of the literature in science education is the vast disparity between the profound and truly important nature of the questions raised by the philosophers working in the field and the too-frequently trivial empirical studies conducted by the empirical researchers in the field. For example, the enormous emphasis placed upon the importance of the structure of the subject matter should have generated far more empirical research studying the understanding of structure as a criterion variable. Instead we have a proliferation of theoretical pieces on this topic but precious little empirical study" (1973:1138).

Roberts and Russell (1975) reinforced this, stating that:

> "science education research has not produced clear results readily applicable to practice; therefore theoretical perspectives need to be developed in order to achieve systematically analyzed science education phenomena".

In this study, use was made of the principle enunciated by Roberts and Russell (1975) that selection of the basis for developing a theoretical perspective appropriate to science educational research be guided by a demonstrable linkage of issues of everyday science education practice.

Some formal analysis (Kneller, 1966) was done also in the systematic scrutiny of existing knowledge in the fields of science and education, but in general, was of little real value. It was necessary to use a mode of analysis which was more oriented to general life and concerned with values--informal analysis.

Informal analysis, as defined by Kneller (1966) is concerned with systematic conceptualization of the actual usage of terms employed to discuss important events in educational practice. Kneller reinforces this as follows:

> "Of the two analytic movements informal analysis has answered more readily to the needs of education. The reason is not difficult to find. The discipline of education is highly practical, in the sense that the process it studies (that of being educated) is an eminently normal experience in the life of every person. As a discipline, too, it is to a large extent prescriptive, since its raison d'etre is the improvement of what it studies, namely the actual methods used here and now to education" (1966:207).

Kneller is quick to point out that the term informal should not make researchers uncomfortable since the term refers to that which is analyzed, not the results of the analysis.

It is through the informal analysis of science education in Canada and those relationships that it encompasses that a theoretical perspective for a Canadian context for science education was developed.

STAGE II: Validation of the Initial Draft of the Theoretical Perspective

In this stage, the initial theoretical perspective was distributed to science educators and science graduate students at the University of Alberta. They were asked to react to the theoretical perspective and comment on the document. They were asked to give their contentions, support, notes on errors or omissions, need for additions or whatever reactions were solicited by the perspective. A copy of the covering letter indicating this is included in Appendix II.

Sample Selection and Procedure

The criteria established for the selection of the validators for the pilot reaction to the initial theoretical perspective developed in Stage I were as follows:

(1) The validator is a graduate student or faculty member at the University of Alberta in secondary or elementary education.

(2) The validator has practical classroom teaching experience in elementary, junior high school or senior high school science or affiliated areas.

A list of validators was compiled from inspection of the organizational structure and membership in the two departments, elementary and secondary education. No attempt was made to obtain a random or unbiased sample. It was felt that with the open ended responses allowed, contributions of each of the validators would reflect their reactions.

The list of validators was kept to 20 names. Half of these were graduate students while the other half were faculty members at the University of Alberta. This was done in an attempt to have a representative sample of the two components of these departments. It was not possible to have a representative number of validators from elementary science education due to the limited number of individuals available. The structure of the sample of validators is shown in Table 1.

Each validator received a copy of the initial theoretical perspective and was asked to respond according to the covering letter of which a copy, as indicated earlier, may be found in Appendix II. This part of the procedure only asked for a written response. In addition, each of the pilot validators was invited to a reaction session to discuss the theoretical perspective. A copy of the invitation which was extended to members of the Ed. C.I. 570 class (already graduate student validators) and the remaining validators is also included in Appendix II.

At the open reaction session, validators were asked to comment freely and question the researcher with regards to the theoretical perspective. This was to encourage those validators who would not otherwise have taken the time to supply a written reaction. Those

TABLE 1

Distribution of University-Based Validators in Stage II

Position in the University	Number in Group	Invited Written Response	Invited Oral Response
Graduate Student *Secondary Science Education	7	7	7
Faculty Member *Secondary Science Education	5	5	5
Graduate Student Elementary Science Education	2	2	2
Faculty Member Elementary Science Education	4	4	4
Graduate Student **Affiliated Science Areas	1	1	1
Faculty Member **Affiliated Science Areas	1	1	1
TOTAL	20	20	20

* Secondary science education includes both junior high school sciences and senior high school sciences.

** Affiliated science area is aerial photography interpretation and LANDSAT imagery interpretation.

reactions were tape-recorded and were included in the reactions used as a basis for revision of the Stage I version of the theoretical perspective.

STAGE III: Revision of the Initial Draft of the Theoretical Perspective

When the deadline for receiving the written reactions had passed with an allowance of two weeks and following the reaction session, the comments and reactions of the validators were studied by the researcher and his advisor. These comments will be referred to in Chapter IV of this study.

On the basis of those comments and further extensive literature research which was directed by questions raised and points made by the validators, the initial theoretical perspective was revised substantially. It was also necessary to ensure that the revised theoretical perspective would keep abreast of new information coming to light with the current emphasis in research prompted by the Science Council of Canada. This revised version, included in Appendix III, may be compared with the outline of the initial theoretical perspective indicating a change in the thrust or direction of the theoretical perspective. This change will also be discussed in Chapter IV.

STAGE IV: Validation of the Final Draft of the Theoretical Perspective

In this stage, the revised version of the theoretical perspective was sent out to selected members of the science and science education community across Canada. They were asked to respond to the perspective in writing to include their contentions, support, criticisms, and comments regarding the perspective. Since the study at this point is more oriented toward the determination of the status of the phenomenon of science education in Canada, rather than an empirical isolation of causative factors accounting for its existence, it was considered that an open, subjective format of response would be most appropriate.

Sample Selection and Procedure

Three criteria were established for the selection of the validators across Canada, with a person having to satisfy at least two:

1. (1) The validator is or has been actively engaged in teaching science or in a support area of science education.
2. (2) The validator is familiar with the state of science education in Canada.
3. (3) The validator is familiar with the state of science in Canada.

The list of validators was compiled from an inspection of available lists of Canadian science educators, lists of members of the Canadian Science and Technology Historical Association, Provincial Science Teachers' Association memberships, and lists of science curriculum consultants.

To provide as representative a sample as possible of those sectors in science and education who have an integral interest in the context of science education in Canada, the validators were placed in three categories. The first category, Canadian science educators included science educators at universities, colleges and research institutions.

The second category, science teachers, included practicing science teachers in public or private schools, as well as science teachers who are now serving as science supervisors with school boards, science teachers who are also graduate students, and science teachers who are acting as science consultants for field service branches of provincial education ministries. The third category, scientists, historians, philosophers and significant others, included all those involved in scientific research, border areas of science or science education, history of science, philosophy of science or other related areas.

The list of validators was kept to 40 names in each of the three categories. No attempt was made to obtain a random or unbiased sample. However, attempts were made to obtain a representative sample of geographical location of validators in each category to ensure different regional aspects would be included. This, unfortunately, was not entirely possible due to the difficult task of locating such people in the given timeframe of the present study. Also, in the case of the science teachers, the attempts to contact provincial science teachers' associations did not for various reasons, yield the names of teachers interested in taking part in this study. Therefore, that particular group is composed primarily of Alberta science teachers. The distribution of validators selected for Stage IV validation is shown in Table 2. From this table it is evident that each of the provincial regions has representation in at least one of the three categories. It is also evident though that almost half of the selected validators are from Alberta with the next greatest representation from Ontario. This imbalance is primarily due to the imbalance in science teacher category and the availability of individuals in the selected categories.

TABLE 2

Geographical Distribution of Validators Selected for Stage IV

Category	Number in Group	Geographical Location										
		B.C.	Alberta	Sask.	Manitoba	Ontario	Quebec	Nfld.	P.E.I.	Nova Scotia	New Brunswick	*Other
Canadian Science Educators	40	6	12	2	1	10	3	3	0	2	1	0
Canadian Science Teachers	40	1	36	0	0	1	0	0	0	1	0	1
Scientists, Historians, Philosophers and Significant Others	40	4	11	2	2	15	1	0	1	2	0	2
TOTAL	120	11	59	4	3	26	4	3	1	5	1	3

* Other includes areas in the Northwest Territories, Yukon, or those who now live outside Canada but are still involved in aspects of Canadian science education, or science which they were initially involved with in Canada.

Each validator received a copy of the revised theoretical perspective, included in Appendix III of this study, and was asked to respond according to the covering letter, of which a copy is included in Appendix IV. The validators were requested to respond in an open subjective style to ensure they were not restricted in their comments.

When the deadline for receiving reactions was past, a follow-up cover letter, also included in Appendix IV, was sent to non-respondents encouraging them to submit their reactions to the perspective.

After allowing another period of approximately one month for late returns, all the reactions of the revised theoretical perspective were examined for comments by the researcher. These comments are given verbatim in Appendix IV and will be discussed in Chapter IV of this study. The identities of the validators have been indicated only by group number and manner in which they are associated with science or science education.

STAGE V: Development and Validation of the Clue Structure

To make the theoretical perspective a useful tool in the assessment of instructional materials, it is essential to develop a clue structure as suggested by Roberts and Russell (1975). This clue structure consists of a set of statements which reflect elements of Canadian context in science education.

Following the format in the theoretical perspective, the clue structure statements are of two types: substantive and methodological. The only criterion used in identifying clue structure elements was that the foundational ideas in the theoretical perspective were self-evidently important in defining a Canadian context for science education (e.g., inclusion of the history of Canadian science in the science curriculum; inclusion of study of the local environment). The clue structure statements derived from the theoretical perspective will be discussed in Chapter IV.

In the actual application of the clue structure to assessment of curriculum materials it is useful to transform the statements into questions, which, when answered, will provide specific information about the instructional materials with relation to the various aspects of Canadian context. In the course of repeated application to teaching materials the clue structure may be refined to improve its capability to account for a Canadian context in science education. Roberts and Russell suggest that the result of this endeavor "is a systematically examined phenomena of science education practice with a three-fold payoff. The research findings are significant in their own right, they establish a solidly conceptualized basis for empirical studies, and they constitute a useful tool for science teacher education" (1975:115).

Validation of the clue structure was sought by using a survey questionnaire (see Appendix V) which asked science teachers to indicate the elements they felt should be included in teaching science education in a Canadian context. The data collected were subjected to multivariate statistical analysis to determine if there are relationships between the elements of the clue structure as indicated by teachers' support of them. Statistical analysis was used to determine if there were significant differences in support of elements of the clue structure by science teachers representing different science disciplines and different levels of teaching experience.

The Survey Questionnaire as an Instrument of Validation

The limitations placed on the researcher, particularly that of time, led to the selection of a questionnaire as the instrument to be used in validating the clue structure since it permits wide coverage at minimum expense in both money and time.

The advantages and disadvantages of using the questionnaire may be compared. Some advantages of questionnaires are (Mouly, 1978):

(1) May elicit more candid replies.

(2) Permits more considered answers.

(3) Allows greater uniformity in the way questions are asked.

(4) Ensures greater comparability in the responses.

Opposing disadvantages of questionnaires include (Mouly, 1978):

(1) The investigator is not permitted to note reluctance or evasiveness of respondents.

(2) The investigator is not allowed to follow through on misunderstood questions or inadequate answers.

The questionnaire constructed was of both the open and closed format. Mouly (1975) suggests that such a combination of the open and closed questionnaire is generally better than the exclusive use of one for a number of reasons. The closed questionnaire

(1) makes for greater coverage and more likely returns;

(2) allows more systematic tabulation;

(3) with its list of alternatives, structures the concept under study and minimizes the risk of misinterpretation.

On the other hand, the open questionnaire

(1) allows the respondents to clarify their position with regard to some of the items;

(2) allows the respondents more leeway in stating their position.

The first and major portion of the questionnaire was closed, providing the respondent with 15 elements which were to be rated as to whether they should be included in a Canadian context for science education. Since this portion of the present study asks the participant to make choices which center on affective components of interests and values, selection of a method of data collecting was very important. The method of collecting data selected involved the use of a modified Likert scale, a response format calling upon the science teachers and prospective science teachers to rate a series of statements, representing elements in a Canadian context for science education in terms of degrees of reaction. Doran (1980) and Mouly (1975) note that inventories of this kind allow answers to complex aspects of a problem since they frequently elicit more valid responses and are less frustrating to the respondent. The five-point scale was chosen since it has proven to be highly appropriate to eliciting information within the affective domain.

An opinion element was included in the closed portion as a separate sixteenth item (see Appendix V). This opinion element was included to measure the support for the clue structure elements as a unit and to encourage participants to use the open portion of the questionnaire.

The second section of the questionnaire was open, with space provided for the participant to identify considerations which should be included in a Canadian context for science education. The wording of the request was such that, provided with some direction for an open response, it was felt by the researcher that participants would be more likely to contribute their opinions.

The matter of reliability and validity of the questionnaire must be viewed in a somewhat unorthodox sense. It would be possible to measure the consistency of responses by the sample of teachers by administering the questionnaire on two separate occasions. This was deemed difficult to do owing to the lack of time and the apparent reluctance of teachers to respond to questionnaires. As was mentioned in Chapter I validity is defined in this study as a measure of teachers' agreement with the clue structure statements for a Canadian context in science education. In a sense, therefore, what is measured by the questionnaire is "content" validity (Mouly, 1975).

Sample Selection and Procedure

In order to determine the effect of teaching experience on perception of importance of elements in a Canadian context for science education, the researcher decided to include both prospective science teachers and practicing science teachers in his sample. The prospective science teachers were those enrolled in science methods and practicum courses during term 2 of the 1981-82 session at the University of Alberta. The sub-sample consisted of prospective students in elementary science, environmental science, biological science and physical science with the number in each category given in Table 3. Due to the limited number of students involved in these science method programs for student teachers, students registered as physical science majors were combined with general science majors since both were receiving instruction in the same science methods class.

The sub-sample of practicing science teachers consisted of the cooperating teachers in the practicum for the prospective science

TABLE 3

Distribution of Stage V Participants Within the Science Teaching Field

Position in Science Field	Number in Group	Number Approached in Stage V
Prospective Environmental Education Teachers	21	21
Prospective Elementary Science Teachers	15	8
Prospective Physical Science Teachers	16	16
Prospective Biological Science Teachers	18	17
Practicing Senior High School Biology Teachers	18	17
Practicing Senior High School Physical Science (Chemistry and Physics) Teachers	16	16
Practicing Junior High School Biology Teachers	17	17
*Practicing Junior High School Physical Science Teachers	16	16
TOTAL	137	128

* includes earth science teachers.

teachers in the biological and physical science programs. The environmental science students were not in a student teaching program during the time the questionnaire was administered. It was not possible to arrange for elementary cooperating teachers to take part in the study. The numbers of practicing teachers involved in the study are also indicated in Table 3.

To contact the practicing teachers, it was necessary to request permission through the University of Alberta's "Cooperative Activities Program". Each of the school districts involved (Edmonton Public School Board, Edmonton Catholic School District and St. Albert Protestant Separate School District No. 6) granted permission to contact the selected teachers. Copies of the Cooperative Activities Program form and the subsequent school district responses are included in Appendix V.

The selected teachers were approached through their appropriate school boards initially. A covering letter explaining the purpose of the study as well as complete directions was supplied to each of the teachers with a copy of the survey questionnaire. Copies of the questionnaire were provided to teachers who did not receive one through the initial channel. This was done by the prospective science teachers.

The questionnaire was administered to the prospective science teachers in their regular methods classes, either by the researcher or the instructor of the class. The differences between the number in Table 3 for the prospective elementary science teachers group is due to the unavailability of seven students. These students were working in individual areas of study at the time the questionnaire was administered. The discrepancy between the number in groups and number approached in the biological science was due to the unavailability of a student who later withdrew. Since only cooperating teachers of students approached to take part in the study were contacted, this reduced the number by one.

After completion of the student practicum period, which was the date set for returns, those teachers who had not returned their questionnaires, by mail or via their student teachers, were contacted personally and encouraged to respond. After another period of one month, the deadline for submission was declared by the researcher to have been reached and the questionnaires were examined by the researcher.

Treatment of the Data

The participants' responses to the statements of the questionnaire were recorded for the first 15 items by assigning a value of one to the low end of the response (strongly disagree) and a value of 5 to the upper end (strongly agree) with intermediate points 2, 3, 4 being assigned to the rank order in between. This was done in this manner to avoid confusing negative values in the statistical analysis. Analysis of the opinion statement was considered in addition to and separate from the elements of the clue structure.

Reactions to and comments made in the open portion of the questionnaire were noted. These are included in Appendix V as "Written Comments Made by Survey Participants". These will be discussed in Chapter IV of this study.

Data from the Stage V questionnaire was subjected to two separate instruments of Multivariate Statistical Analysis devised by the Division of Educational Research Services, Faculty of Education, at the University of Alberta.

(1) A factor analysis package (FACT 20) was used to subject the data to factor analysis using principal axes with iteration as the method of factoring and varimax rotation. By generating the covariances and correlations among the responses, it is possible to obtain a description of the dependence structure and note latent factor variates (Morrison, 1976).

(2) A One-Way Multivariate Analysis of Variance and Covariance (MULV 16) was used to test the following series of related null hypotheses which together serve to validate and support the clue structure.

Ho_1: There is no difference in support of elements to be included in a Canadian context for science education by prospective biology teachers, prospective physical science teachers, prospective elementary science teachers, or prospective environmental education teachers.

Ho_2: There is no difference in perception by the four groups of prospective science teachers for inclusion of elements in a Canadian context as represented by the variables identified in factor analysis.

Ho_3: There is no difference in perception of elements to be included in a Canadian context for science education by prospective biology teachers and practicing senior high school biology teachers.

Ho_4: There is no difference in perception of elements to be included in a Canadian context for science education by prospective physical science teachers and practicing senior high school physical science teachers.

Ho_5: There is no difference in perception of elements to be included in a Canadian context for science education by prospective physical science teachers and practicing junior high physical science teachers.

Ho_6: There is no difference in perception of elements to be included in a Canadian context for science education by prospective biology teachers and practicing junior high school biology teachers.

Ho_7: There is no difference in perception of elements to be included in a Canadian context for science education by junior high school biology teachers, junior high school physical science teachers, senior high school biology teachers, and senior high school physical science teachers.

The preceding null hypotheses illuminate the interrelationships of perceptions of the science teachers of a Canadian context for science education. These relationships are discussed at length in Chapter IV.

Stage V was intended to not only validate the clue structure for a Canadian context but also to identify areas for further investigation. This is accomplished through the use of factor analysis and was one reason for its selection.

Both of the statistical procedures used in the present study are contained in the D.E.R.S. Library at the University of Alberta. Further discussion of these procedures may be found in Muliak (1972) and Morrison (1976).

Following analysis of the data in Stage V, copies of the analysis were distributed to each of the school districts employing the participating teachers, in accordance with their request under the terms of the Cooperative Activities Program.

CHAPTER IV

Results and Discussion

Introduction

Chapter IV presents the results of the present study in five separate sections, each corresponding to a design stage. Where the results of a stage are too lengthy, they will be presented in their entirety as an appendix, with only essential aspects being included in this chapter.

Stage I Results: Initial Draft of the Theoretical Perspective

The initial draft of the theoretical perspective for a Canadian context for science education was too repetitive of the final draft, hence has not been included as an appendix. However, an outline of this draft is given in Appendix I.

Stage II Results: Validation of the Initial Draft of the Theoretical Perspective

The response from science educators and science graduate students approached at the University of Alberta to serve as validators of the initial theoretical perspective was average. Mouly (1975) suggests an average of 65 percent returns for reputable questionnaires, however, with the limited sample available, the smaller number tends to make percentage returns deceiving. Ten of the 20 university validators offered written responses while 9 of 20 contributed oral responses at the reaction session. The percentage returns of 50 percent and 45 percent are not truly indicative of the participation since some of these contributed in both oral and written form and others contributed to one while not the other. Therefore, Table 4 gives a much better portrayal of the Stage II participation. There was especially good participation from the faculty members teaching secondary science education courses.

The combined reactions of the respondents of Stage II, both written and reaction session verbal comments, to the Stage I draft of the theoretical perspective are included in Appendix II. The major comments which had a decisive role in altering the initial version of the theoretical perspective are as follows:

(1) One must provide a case for Canadian context not out of its opposition to Americanism or internationalism, but simply because it makes good sense. The "Canadianization" of science education ought not to be an emotional, or political matter, but simply one of good sense. There is a need for a list of ways in which science, and science education could be "Canadian". If one could make such a list and argue dispassionately in favour of including these factors in science education, then and only then, could a Canadian context for science education be accepted.

(2) There is a need to show that apparent deficiencies could not be attacked without using the club of Canadianization. What is needed is a more philosophical and less political style of argument. The problem ought not to be a political one but an educational one.

(3) In the theoretical perspective, there is a need to distinguish between basic and applied science. Also there is a need to define what is meant by a national or cultural dimension of science.

TABLE 4

Distribution of Responses From University-Based Validators in Stage II

Position in the University	Number in Group	Written Responses	Oral Responses
Graduate Student *Secondary Science Education	7	3	5
Faculty Member *Secondary Science Education	5	4	3
Graduate Student Elementary Science Education	2	2	1
Faculty Member Elementary Science Education	4	0	0
Graduate Student **Affiliated Science Area	1	1	0
Faculty Member **Affiliated Science Area	1	0	0
TOTAL	20	10	9

* Secondary science education includes both junior high school sciences and senior high school sciences.

** Affiliated science area is aerial photography interpretation and LANDSAT imagery interpretation.

(4) There is a need to relate relevance to Canadian identity. There were too many strands of argument which needed to be more clearly restated.

(5) There was general concern that the length of this paper will work against its being carefully read by very many people. Therefore, there is a need to shorten it or provide summaries at the end of each major section. It would help readers keep the major ideas in focus.

Stage III Results: Revision of the Initial Draft of the Theoretical Perspective

On the basis of the reaction from the Stage II validation process and further literature research, the Stage I draft of the theoretical perspective on a Canadian context for science education was revised. The revised draft is presented in Appendix III.

A comparison of the outline of the initial draft given in Appendix I with the outline of the revised theoretical perspective in Appendix IV will incidate the direction and extent of the revision. Specifically, the following major revisions were made:

(1) In order to shorten the paper and make the perspective more succinct, portions of the initial draft perspective were omitted. This is especially noticeable in the exclusion of Implications of a Theoretical Perspective on Canadian Context for Science Education.

(2) The "nationalistic" or polemic manner noted in the initial draft was removed and replaced by a more objective and philosophical view of the problem being investigated.

(3) Supporting evidence of the need for inclusion of components of the perspective was included.

(4) An attempt was made to clarify definitions of national and cultural dimensions of science. Some initial draft contentions rested in two basic controversies which needed to be studied further. The first was the notion of Canadian science, Canadian science education, and the relation of "national" to science. Most of this rested in clarification of definitions. The second point to consider was the argument centering around national versus international conceptions. Here again it seems the major problem dealt with definitions, which were clarified.

(5) In the revised version of the theoretical perspective there was a concentrated effort to show in a progression of logically supported arguments that there is a need for inclusion of a Canadian context for science education and what this context includes.

These revisions resulted in the revised theoretical perspective used in Stage IV of the study (see Appendix III).

Stage IV Results: Validation of the Final Draft of the Theoretical Perspective

Of the 120 validators (see Table 2) across Canada selected and mailed copies of the revised theoretical perspective, 44 responded. This response, illustrated in Table 5 does show the sample has good representation of the geographical regions of Canada with only representation from Manitoba and Prince Edward Island not available. In each of the other cases, at least one category was represented by the other provinces. The distribution of percentage response, shown in Table 6 indicates a total response of 36.7 percent. The percentage response for each category is indicated by province as a percentage of

TABLE 5

Geographical Distribution of Validators Responding to the Revised Theoretical Perspective

Category	Responses in Group	Geographical Location										
		B.C.	Alta.	Sask.	Manitoba	Ontario	Quebec	Nfld.	P.E.I.	Nova Scotia	New Brunswick	*Other
Canadian Science Educators	15	1	6	2	0	2	1	2	0	0	1	0
Canadian Science Teachers	16	1	12	0	0	1	0	0	0	1	0	1
Scientists, Historians, Philosophers and Significant Others	13	0	4	1	0	6	0	0	0	0	0	2
TOTAL	44	2	22	3	0	9	1	2	0	1	1	3

* other includes areas in the Northwest Territories, Yukon, or those who now live outside Canada but are still involved in aspects of Canadian science education vs. science which they were initially involved with in Canada.

TABLE 6

Distribution of Percentage Response of Validators Contacted in Stage IV

Category	Group Responses	Geographical Location										
		B.C.	Alta.	Sask.	Manitoba	Ontario	Quebec	Nfld.	P.E.I.	Nova Scotia	New Brunswick	*Other
Canadian Science Educators	37.5	16.7	50.0	100	0	20	33.3	66.6	NOI	0	100	NOI
Canadian Science Teachers	40.0	100	33.0	NOI	NOI	100	NOI	NOI	NOI	100	NOI	100
Scientists, Historians, Philosophers and Significant Others	32.5	0	36.4	50	0	40	0	NOI	0	0	NOI	100
TOTAL	36.7	18.2	37.3	75	0	34.6	25	66.6	0	20	100	100

* as defined for Table 5.

NOTE: (1) all figures presented here are in percent.
(2) N.O.I. - No percentage available since no respondents in this particular category were included.

the number of validators initially contacted for that specific province and category. For example, in British Columbia, 6 Canadian science educators were contacted while only one responded. This resulted in the percentage response for science educators in British Columbia being 16.7 percent compared to the percentage response of 37.5 percent of the total Canadian science educator category.

Due to the small numbers in the category and geographic representation, the percentage values may be confusing since in some cases the number of individuals contacted may have been one. It is therefore necessary to consider both Table 5 and Table 6 when commenting on the validation response. This is especially noticeable with respect to returns from British Columbia, Saskatchewan, Ontario and New Brunswick which show returns in some categories of 100 percent compared with those of Prince Edward Island which had 0 percent response. This was due to the fact that it was possible to seek only one response from Prince Edward Island.

The greatest number of returns, 22, were from Alberta which had the greatest number solicited, 59, for a 37.3 percent response (which was similar to the total response). Ontario had 9 responses with the other provinces contributing responses ranging from zero to 3. The Maritime provinces, Saskatchewan and Newfoundland, as well as those validators in the category "other" (Northwest Territories, Yukon, or outside Canada), although small in the number solicited, seemed to show the greatest interest in responding.

Among the three categories used to classify the national validators, the most responsive was the Canadian science teachers group with 16 of the solicited 40 for a 40 percent response. Canadian science educators were next with 15 of 40 for a 37.5 percent response and then scientists, historians, philosophers and significant others with a 32.5 percent response based on 13 returns of 40 solicited.

The number of responses was limited, as noted by many respondents, because the reactions were solicited during the busiest portion of the academic year. Unfortunately, it was necessary to conduct the study at that time to facilitate the researcher's program of study.

The number of responses for each category is not indicative of the calibre of response, and may also be misleading if one were to speculate that number or percentage of responses was indicative of the contribution to the validation of the theoretical perspective. Each of the written responses, with in some cases additional oral comments by validators, were carefully examined and noted. These reactions have been included verbatim in Appendix IV rather than this chapter, due to the extensive comments and reactions made.

The reactions in Appendix IV have been directed to specific sections of the perspective to which they were addressed by the validators or as general comments, depending upon the context in which they were received. The headings used for reference correspond to headings used in the revised perspective with the addition of the general comment category. As noted in Appendix IV, reactions are given in a manner which reflected the category the validator represented and a subscript denoting the sequence number of the response within that category:

(A) Canadian Science Educators

(B) Canadian Science Teachers

(C) Scientists, Historians, Philosophers, and Significant Other.

The major reactions of the validators to the final version of the theoretical perspective are as follows:

1. There was a high level of agreement from validators. Several totally agreed with the general position presented by the theoretical perspective. This was clearly indicated by remarks such as the following:

   > "I agree with the overall thrust of your argument and I think that the kind of education you propose is very important to the future of the country".

   > "I think that you are trying to do something that is critically important".

   In the majority of cases, the validators implied varying degrees of support for the perspective. They would object to some sections but support others. A few validators, through their written comments and the tone reflected in these comments, expressed considerable disagreement. The following is an example:

   > "I have deeper concerns over science education than the inadequate emphasis of Canadian context in science education. I should make the general comment at the outset that I am not overwhelmingly enthusiastic about an emphasis on the "Canadian context" for science education".

   A reading of the entire set of validators comments (Appendix IV) gives one the impression that the greatest support for the theoretical perspective comes from the category which includes scientists, historians, philosophers and significant others. The least support seems to come from the Canadian science educators. The difference in apparent support of the two categories of validators may be an "accident" resulting from the non-random selection of validators.

2. The inclusion of Canadian identity in the theoretical perspective was a controversial issue. A few validators supported the idea

but most who commented on the issue were negative about invoking a national identity for science and science education. The following are examples of the latter reaction:

> "On page 7 you assume that a Canadian context for science education for the sake of a Canadian identity is desirable and necessary. I strongly disagree. This philosophical bias attempts to convert science education into the service of Canadian politics with little concern over the relevant educational needs of the students or the reasonable understanding of the nature of science".
>
> "May I condemn the goal of seeking a Canadian identity. In its place, I advocate serving the needs of the students and promoting locally developed science courses, etc."
>
> "First, I think, because I don't think the Canadian identity is an issue; and secondly, because I believe that there are other important (if not prior) aims for science education in Canada".
>
> "On page 4 there is an explicit appeal to use science instruction as a vehicle for promoting Canadian national identity. I'm glad that you state clearly what the goal is. Certainly such a goal will seek to ignore the international nature of science, will avoid evaluating curriculum materials on the basis of their excellence to provide concepts of science, and will seek to replace rigorous, abstract science with discussions of localized technologies".
>
> "Seeking the Canadian identity is questionable".

3. There was substantial support for the view of Brouwer (1980) presented in the theoretical perspective as shown by the following statements:

> "I must say 'Amen' to the view of Brouwer that since science has shown itself to be potentially at least an area in which men of all nations can work together, the Canadianization of scientific research and education must not be carried out for 'nationalistic' reasons but simply because science and technology can best show their value to all people if they are applied first of all in the local setting in which the research and teaching is carried out".

4. The issue of national versus international character of science was controversial, with an integration of the national and international being strongly advocated. The following statements indicate several aspects of the controversy over this issue:

> "Ensuring a sense of internationalism combined with one of nationalism is a very important positive feature".
>
> "I agree with your summary on pages 13 and 14 of the national versus international character of science and certainly hope that there is a blend of national and international components in the field of geology".
>
> "You have overstated the uniqueness of Canada, I think. You have presented an excellent argument for teaching science in a social context, but most of the time, your argument would be unaffected by removal of the word "Canadian". The curriculum needs to include the history of Canadian science, and examples of contemporary Canadian science, but a lot of what you seem to be asking for looks international to me".
>
> "The evidence quoted from Peterson in support of the uniqueness of Canada on page 26 is accurate for most of the developed world, not just Canada".
>
> "We must not limit examples to local ones only--the problems are global, as are the implications of what we do".
>
> "A certain amount of theoretical background is necessary for understanding (what is involved in the fission or fusion of atomic nuclei--certainly these are universal facts). If, beyond that, we were to emphasize only Canadian nuclear science we would find ourselves focussing on uranium mining and Candu reactors--and ignoring the nuclear arms race and radioactive pollution. This kind of one-sided view is not what I would like to see secondary school science teachers impart!"

5. There did seem to be a high level of agreement for inclusion of technology in science education. This is demonstrated in the following statements:

> "Page wants technology introduced within our teaching of science courses. This is good and I strongly agree".

> "One has a better chance in bringing in the Canadian contribution in the field of Technology. But while I think the technological aspect has its rightful and necessary place in the Canadian School System and even as part of the science curriculum, the "substantive" as well as the "syntactic" structure of technology is different enough from that of science in general that it deserves special attention."

> "I also agree that of great importance to a Canadian context for science education is stressing the interrelationship of pure and applied science, so that emphasis is also placed on the concern that science be taught in such a way that issues of pressing national concern relating to science and technology receive a central place in the classroom experience of students".

6. There was a high level of agreement by the validators for the inclusion of emphasis on the science-society interaction in science teaching as indicated by the following statements:

> "Presenting science education as being the discipline concerned with the interface between science and society is good stuff".

> "Agreed! A holistic view of the nature of science and its relation to Canadian society should be a goal for all citizens, not just scientific!"

> "Because social context is largely absent, the majority of Canadian society is alienated from science and hence the need for public awareness of science".

Problems regarding implementation of a science-society program were also noted by some validators, as the following statement shows:

> "As for your point that science-society interaction is virtually absent in science teaching in Canadian schools, try writing a curriculum document or text that dares to tread into the societal realm. I have. They are severely attacked by reviewers at the manuscript stage. Most government education ministries and schools seem to want content and little more".

7. The strongest agreement of validators was found in support of maximum use of the local environment and application of science to

the student's immediate environment. This is indicated by the following statements:

> "As far as I am concerned the 'Maximum use of the Local Environment' section is probably the most important thing you're saying. It begins to get at the life-world of the child. Whether science makes sense to him or her and if it relates to everyday life, would be my motivation for coming to the notion of Canadian context".
>
> "I believe that science educators should be able to use examples of the applications of scientific principles that are close at hand and meaningful to the students. Automatically then, science education in a Canadian school would have some Canadian context".
>
> "If there is to be in science education a proper consideration of the application of science, then teachers must be expected to and able to apply the scientific principles they are talking about to their immediate environment".
>
> "Having students do their own investigations relevant to their social, physical and biological environment to achieve a realistic frame of reference on the purposes and potential of science are goals which I can heartily support".

8. There was a high level of agreement expressed by validators for the use of Canadian produced materials. This was mixed with various individual concerns as noted in the following statements:

> "Secondly, a universal cry for Canadian materials in all subject areas is apparent in my travels. Science seems to be frequently on the back burner in the Canadianization concerns with curricular materials".
>
> "It is true that very few Canadian texts are suggested as readings and that few recommendations on Canadian context were followed in the Ministry but new revisions in Alberta and British Columbia are leaning in that direction. The danger is "provincialism" with the possible loss of Canadianization".
>
> "Yes! There are very few Canadian texts as suggested readings for students and the guidelines do not reflect a Canadian context other than in the most perfunctory way".

9. The inclusion of the history of Canadian science in a Canadian context for science education was a controversial issue with extremes of support for this may be noted from the following:

> "Yes! If students of science education in Canada are to understand the course science has taken in Canada and our present emphasis on natural resources, they must be aware of the tradition in which science is done in Canada".
>
> "And, of course, I'm glad that you assert the importance of the history of science--I urge you to consider this for students of history at least as much as for students of science".
>
> "The history of Canadian science is deadly! I would hate to teach it!"

10. A number of validators remarked about the central role of teachers in any move towards inclusion of Canadian context in science education. The following statements are typical:

> "Instructional materials play a very central role but the teacher is the one who implements this material within the context of the classroom, school, community, etc. It is my experience that too many teachers (and therefore, students) are too strictly tied to the printed instructional material. In my opinion, instructional materials provide a convenient excuse to detract from a lack of adequate teacher preparation and retraining".
>
> "Why aren't teachers considered as a potential source of curriculum ideas and innovations? Why must major curriculum changes always come from 'university oriented' high profile projects?"

Stage V Results: Development and Validation of the Clue Structure

A total of 15 elements were identified in the theoretical perspective for the clue structure:

(1) An interdisciplinary approach to science education facilitating study of man's interrelatedness with his natural and social environment.

(2) Promotion of an understanding and appreciation of the relationship between science and Canadian society including the impact that science and technology have on Canadian society and culture today.

(3) A depiction of how science and technology can be used to alter the economic and political situation in Canada.

(4) History of Canadian science which includes the impact that science and technology had historically upon Canadian life.

(5) Promotion of an awareness of the role of Canadian scientists and technologists in Canada's growth and development.

(6) Recognition of contributions made by Canadian scientists to international science.

(7) A knowledge of the tradition in which science is done in Canada including present emphasis and philosophy underlying Canadian science.

(8) Acknowledgement of the interrelationship of pure and applied science allowing a description of the world as it is while also showing the means by which the environment is adapted to suit man's needs.

(9) Attention to methods of inquiry which can be used in dealing with pressing Canadian problems which require a scientific/technological solution.

(10) A treatment of Canadian science policy promoting an understanding and awareness of the differential emphasis on certain areas of research in pure and applied science in Canada.

(11) Maximum use of the local environment through experiences and examples using the immediate natural and social world in which the student lives.

(12) Inclusion of topics and problems of current local scientific significance which could include taking feasible action on suggested solutions.

(13) Inclusion of Canadian produced science instructional materials which students may easily relate to their own life and environment.

(14) Provision for teacher's guides to show how foreign instructional materials can be used or supplemented to be considered more in line with Canadian educational circumstances and needs.

(15) A method for bringing the unique problems of each of the major regional areas in Canada together into one context interrelated through common concerns.

These elements include ten (items 1-10) which reflect content components and five (items 11-15) which reflect methodological components of science teaching. Table 7 illustrates the derivation of the clue structure elements, noting the corresponding theoretical perspective component from which each element stems.

Analysis of the Questionnaire Responses

As was mentioned in Chapter III the elements in the clue structure were used in a questionnaire (see Appendix V) for validation by rates of return of the questionnaire are indicated in Table 8. According to Mouly 1979) the overall response of 66.4 percent is considered average for a well prepared questionnaire. The difference in return rates for different groups is due to the manner in which the questionnaire was administered. In the case of the prospective environmental education teachers and the prospective elementary science

TABLE 7

Derivation of Clue Structure Elements in Stage V

Element	Corresponding Theoretical Perspective Component
1	Interdisciplinary Nature of Education
2,3	Canadian Science-Canadian Society Interaction
4,5,6	History of Canadian Science
7	Philosophy Underlying Canadian Science
8	Pure Science, Canadian Applied Science and Their Interrelationship
9	Science as Inquiry
10	Canadian Science Policy, Current Research Emphasis in Canada and Their Interaction
11,12	Maximum Use of the Local Environment
13	Canadian Science Instructional Materials
14	Adaptation of Foreign Instructional Materials to a Canadian Context
15	Problems of Regionalism

TABLE 8

Rates of Return of Stage V Survey Questionnaires

Identified Group	Number of Questionnaires Sent	Number of Responses	Percentage Return	Number With Written Comments	Number With Written Comments As % of Returns
Prospective Environmental Education Teachers	21	21	100.0%	5	23.8%
Prospective Elementary Science Teachers	8	8	100.0%	1	12.5%
Prospective Physical Science Teachers	16	12	75.0%	3	25.0%
Prospective Biological Science Teachers	17	10	59.8%	5	50.0%
Practicing Senior High School Biology Teachers	17	10	58.8%	4	40.0%
Practicing Senior High School Physical Science (Chemistry and Physics) Teachers	16	12	75.0%	3	25.0%
Practicing Junior High School Biology Teachers	17	5	29.4%	1	20.0%
*Practicing Junior High School Physical Science Teachers	16	7	43.8%	3	42.8%
TOTAL	128	85	66.4%	25	29.4%

* includes earth science teachers.

teachers, the questionnaire was administered in regularly scheduled class periods which accounts for the 100 percent return rates. Prospective physical science teachers and prospective biology teachers were surveyed in a similar manner; however, a combination of class administered questionnaires and mail-out questionnaires was required due to the term schedule of the class. This lowered the response rate to 75.0 percent and 58.8 percent respectively.

Practicing senior high school biology teachers and practicing senior high school physical science teachers were contacted by mail and responded either by mail or through the prospective science teacher who was, at the time, their assigned student teacher. It is interesting to note that the percentage returns for those groups are identical to the percentage returns of the prospective science teachers assigned to those practicing teachers. This may imply that those prospective science teachers in biology and physical science who did or did not respond may have influenced the submission of response of the assigned practicing teacher.

The response rate for practicing junior high school biology teachers and practicing junior high school physical science teachers was considerably lower with respective returns of 29.4 percent and 43.8 percent. At the time the questionnaire was administered these two portions of the sample no longer had contact with the prospective science teachers. Therefore, they were contacted initially through their school board, then by mail; non-responses were contacted personally.

Two major reasons given by those contacted for non-response were:

(1) Tired of too many surveys and questionnaires;

(2) No time since it is a very busy time of the shool year.

A small portion of those responding to the questionnaire made use of the open section. Twenty-five of the 85 respondents, or 29.4 percent, made written comments. The range of the number submitting written comments is also shown in Table 8. The range for each group was between 12.5 percent and 50 percent of the respondents from a particular group. The open-ended comments, which are included in Appendix V, reveal the following major points:

(1) Canadian content in science should not limit itself to a study of Canada only. At present Canadian texts are not adequate for the level of attainment which the board of education seeks. If a Canadian context is being developed, a purposeful global context should also be developed. A Canadian context encourages nationalism and the idea that Canadian concerns are more important than other nation's problems. Rather than letting American materials dominate over school systems, a global worldview context should be developed. Science is not nationally oriented but is universal.

(2) Science should stress the interrelatedness of the actions and technological advances of man and their effect on the environment. It should stress the environmental changes as well as the importance of technology, i.e., the impact on citizen lives.

(3) There was strong agreement that meaningful relevant science is that science which can be related to students own experiences in-the-world.

(4) Canadian context could be one context but many others are important, e.g., economic, political, pedagogical, environmental,

societal, consumer, applied, etc. Different societal emphasis would be highlighted in different areas of a science curriculum. The key question is what will be the contextual setting in a given topic. This need not interfere with "real science" concepts.

Validation of the Clue Structure as a Complete Unit

Teachers were asked to react to an opinion statement: "Most of the important considerations for inclusion in a Canadian context for science education have been mentioned" (see questionnaire, following item 15). The statistical results of this opinion statement serve to validate the clue structure as a complete unit. By assigning a value of one to the low end of the response scale (strongly disagree) and a value of 5 to the upper end (strongly agree) with values 2, 3, and 4 being assigned to the ranking order in between, it is possible to recognize values greater than 3.0 as being in agreement and values of less than 3.0 of not being in agreement with the opinion statement. The results of the opinion statement are given in Table 9. The mean score of the total sample measured was 3.9 which indicates support for the statement by approximately one standard deviation unit. The mean value seems to be fairly representative of the sample since the median, mode, and mean value are approximately the same. The unbiased standard deviations were computed according to procedures outlined by Ferguson (1981). One notes that the standard deviation value of the total sample is higher than for most of the individual groups. This is due to the greater variance in values obtained from samples of prospective biological science teachers and to a lesser extent prac-

TABLE 9

Results of the Opinion Question in the Questionnaire

Identified Group	n	Sample Median	Sample Mode	Mean Score X	S.D.
Prospective Environmental Education Teachers	21	4	4	4.3	0.63
Prospective Elementary Science Teachers	8	4	4	3.9	0.64
Prospective Physical Science Teachers	12	4	4	4.0	0.60
Prospective Biological Science Teachers	10	2.5	1	2.4	1.35
Practicing Senior High School Biology Teachers	10	4	4	3.7	0.95
Practicing Senior High School Physical Science (Chemistry and Physics) Teachers	12	4	4	4.0	0.60
Practicing Junior High School Biology Teachers	5	4	4	3.6	0.55
*Practicing Junior High School Physical Science Teachers	7	4	4	4.1	0.38
TOTAL	85	4	4	3.9	0.91

* includes earth science teachers.

ticing senior high school biology teachers. The most striking deviation from the mode and median was that of the prospective biological science teachers. The resultant low mean score of 2.4 is almost two standard deviation units from the mean score of the total sample. This extreme would consequently lower the mean score of the total sample and increase the standard deviation unit value of the total sample. The low mean score for the prospective biological science teachers may be due to a reported irregularity in the administration of the questionnaire to this sub-group.

The support by the other individual groups ranged from mean scores of 3.6 to 4.3. This would indicate that prospective and practicing science teachers represented by this sample are in agreement that most of the important considerations for a Canadian context for science education are included in the 15 clue structure elements presented in the questionnaire.

Validation of Elements of the Clue Structure

Validation of elements of the clue structure took the form of analyzing the degree of support for each of the elements in the clue structure by the prospective science teachers and the practicing science teachers. The first data to be analyzed was that of the prospective science teachers. The pattern of responses to the 15 elements of the questionnaire (a copy of which is in Appendix V for reference) are displayed in Figures 1 and 2 as the mean score responses of the 51 prospective science teachers. It is clearly shown that for all items included as content and methodological components there is agreement that they should be included in a Canadian context

FIGURE 1

SUPPORT FOR INCLUSION OF SPECIFIC CONTENT COMPONENTS IN A CANADIAN CONTEXT FOR SCIENCE EDUCATION BY PROSPECTIVE SCIENCE TEACHERS

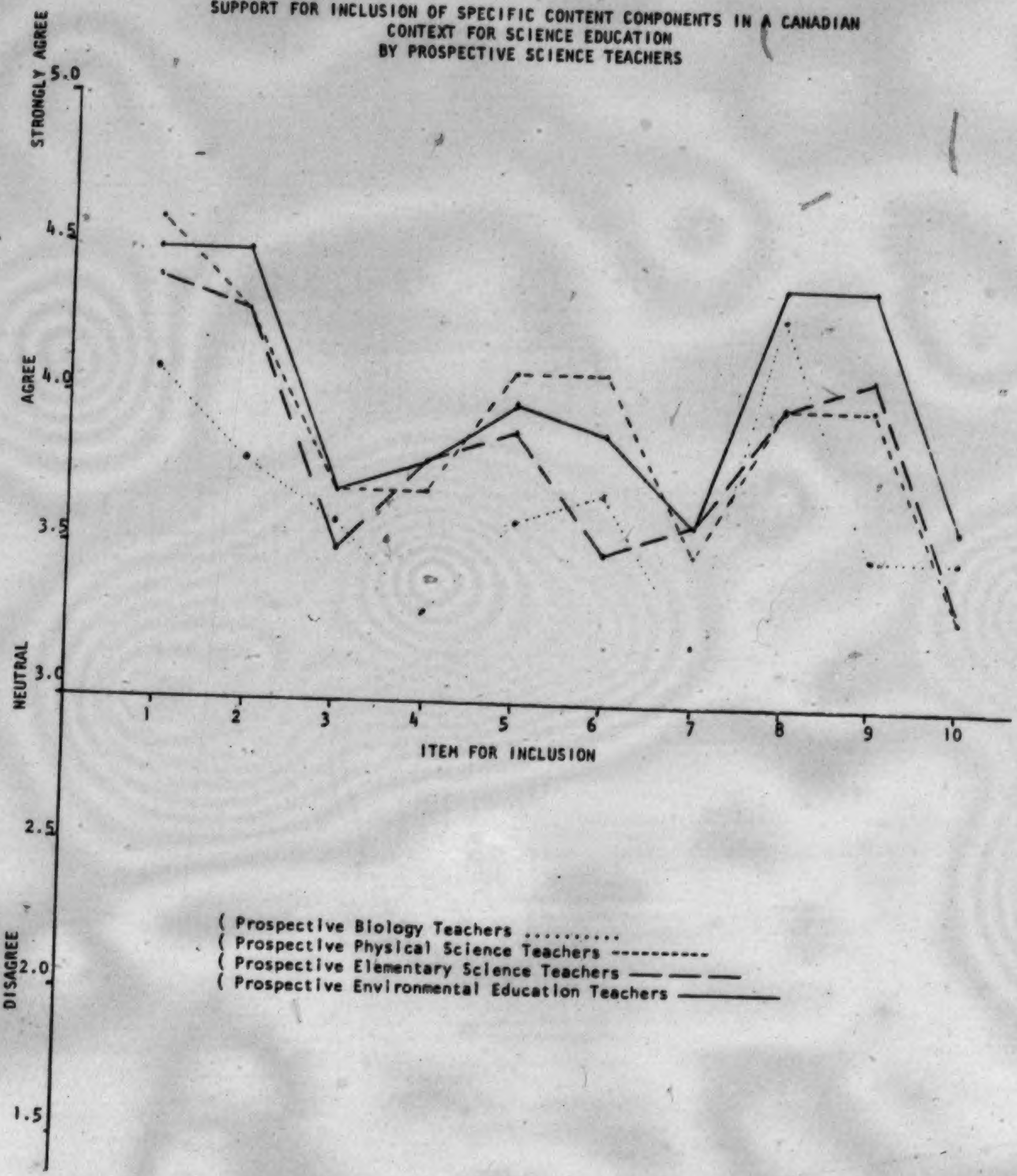
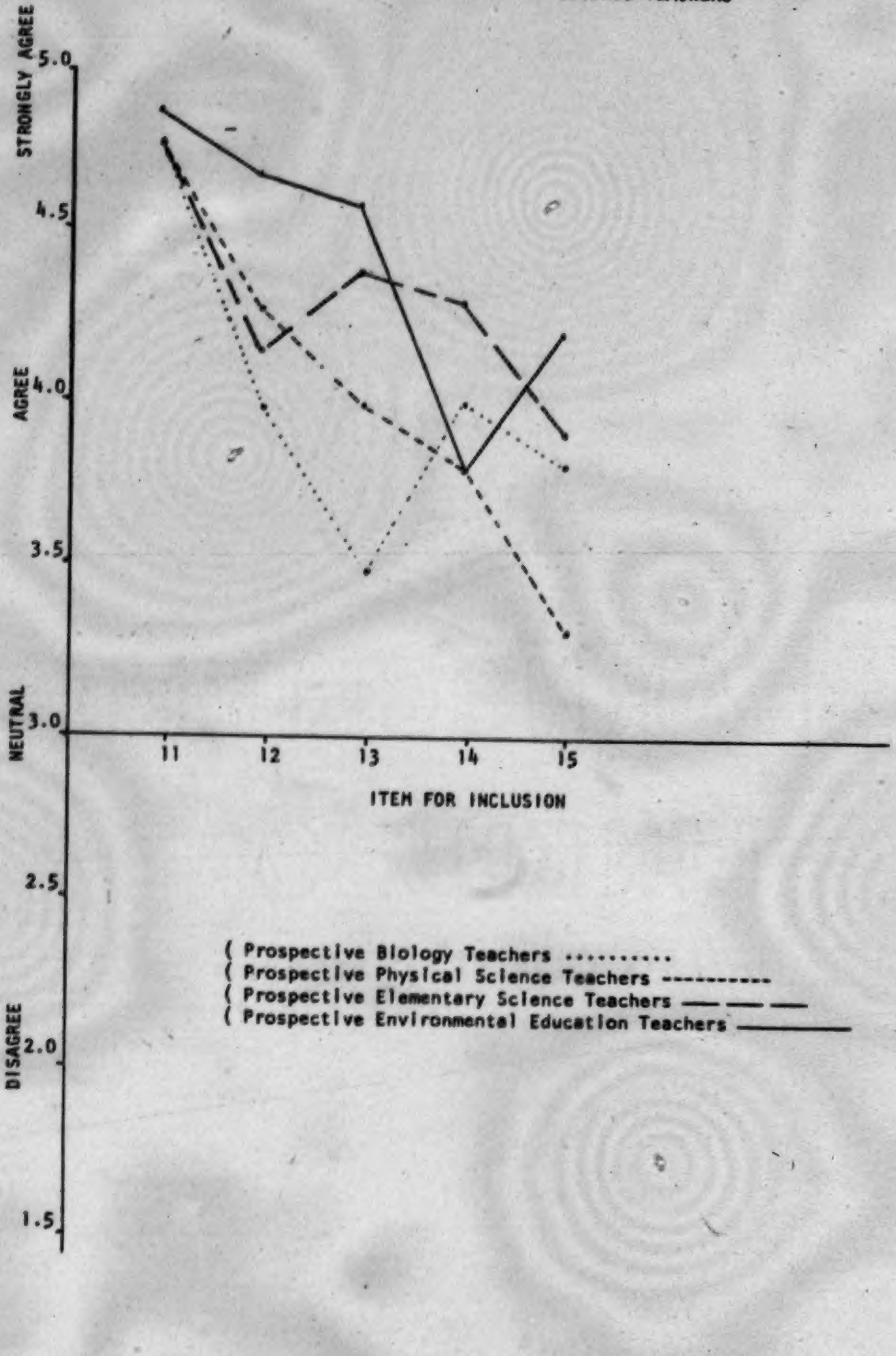


FIGURE 2

SUPPORT FOR INCLUSION OF SPECIFIC METHODOLOGICAL COMPONENTS
IN A CANADIAN CONTEXT FOR SCIENCE EDUCATION
BY PROSPECTIVE SCIENCE TEACHERS



for science education. Construct validity, or the degree to which a related trait is reflected in the performance on a question is reflected in the consistent scoring of each element in excess of the neutral 3.0 value.

Elements may be considered reliable when the identified groups score close together, providing external consistency (Doran, 1980). This suggests that all the items are reliable with the most reliable elements of the clue structure being items:

(3) A depiction of how science and technology can be used to alter the economic and political situation in Canada (Mean range 3.50 to 3.71).

(10) A treatment of Canadian science policy promoting an understanding and awareness of the different emphasis on certain areas of research in pure and applied science in Canada (Mean range 3.25 to 3.57).

(11) Maximum use of the local environment through experiences and examples using the immediate natural and social world in which the student lives (Mean range 4.75 to 4.90).

The least reliable items were items:

(2) Promotion of an understanding and appreciation of the relationship between science and Canadian society including the impact that science and technology have on Canadian society and culture today (Mean range 3.80 to 4.47).

(9) Attention to methods of inquiry which can be used in dealing with pressing Canadian problems which require a scientific/technological solution (Mean range 3.50 to 4.43).

(13) Inclusion of Canadian produced science instructional materials which students may be able to relate to their own life and environment (Mean range 3.50 to 4.619).

This reliability is based on the between groups correlation for each item measured by the support of prospective science teachers.

In terms of validity, the greatest support from prospective science teachers was for item:

(11) Maximum use of the local environment through experiences and examples using the immediate natural and social world in which the student lives (Mean range 4.75 to 4.90).

The next greatest support was for items:

(1) An interdisciplinary approach to science facilitating study of man's interrelatedness with his natural and social environment (Mean range 4.10 to 4.47).

(8) Acknowledgement of the interrelationship of pure and applied science allowing a description of the world as it is while also showing the means by which the environment is adapted to suit man's needs (Mean range 4.00 to 4.38).

(12) Inclusion of topics and problems of current local scientific significance which could include taking feasible action on suggested solutions (Mean range 4.00 to 4.67).

The least support was shown for items:

(7) A knowledge of the tradition in which science is done in Canada including present emphasis and philosophy underlying Canadian science (Mean range 3.20 to 3.63).

(10) A treatment of Canadian science policy promoting an understanding and awareness of the different emphasis on certain areas of research in pure and applied science in Canada (Mean range 3.25 to 3.57).

Further comparison of the support for individual elements of the questionnaire by prospective science teachers is made possible by Table 10. Consistently high mean scores, such as those for item number 1 reflect agreement for inclusion of that item by each of the four groups. The very low variance recorded for item number 1 in both the prospective environmental education teacher group and the prospective physical science teachers indicate a high degree of consensus within each of those groups regarding the value of item number 1 (which refers to an interdisciplinary approach). On the other hand, the high variance within the prospective biological science teachers for the same item indicates that though the mean score was 4.1, there was not the same degree of agreement with individual scores more widely separated.

The greatest mean score values with the least variance for all four prospective science teacher groups was recorded for item number 11 which refers to maximum use of the local environment. Further comparisons can be made between groups, however this is the only item for which consensus of support was found.

The next data to be analyzed was that of the practicing science teachers. This was done in a manner similar to that used for the prospective science teachers. The pattern of responses to the elements of the questionnaire are displayed in Figures 3 and 4 as the mean score responses of the 34 prospective science teachers. In this case there was agreement that all content and methodological components should be included in a Canadian context for science education with two exceptions identified by the same group. The practicing junior high school

TABLE 10

Comparison of Variance Within Groups of Prospective Science Teachers for Support of Elements in Stage V

Questionnaire Item Number (element)	Identified Group of Prospective Teachers in							
	Environmental Education		Elementary Science		Physical Science		Biological Science	
	Mean Score $\bar{X}$	Variance S^2	Mean Score $\bar{X}$	Variance S^2	Mean Score $\bar{X}$	Variance S^2	Mean Score $\bar{X}$	Variance S^2
1	4.476	0.249	4.375	0.484	4.583	0.243	4.100	1.490
2	4.476	0.345	4.250	0.187	4.333	0.389	3.800	1.160
3	3.714	0.776	3.500	0.500	3.667	0.556	3.600	0.440
4	3.810	0.726	3.250	0.437	3.667	1.056	3.300	0.810
5	3.952	0.807	3.875	0.359	4.167	0.306	3.600	0.440
6	3.857	0.884	4.000	0.250	4.167	0.806	3.700	0.610
7	3.571	0.721	3.625	0.484	3.250	1.021	3.200	0.760
8	4.381	0.331	4.000	0.250	4.000	0.833	4.300	0.210
9	4.429	0.340	4.125	0.359	4.000	0.667	3.500	0.450
10	3.571	0.626	3.250	0.437	3.333	0.722	3.500	0.650
11	4.905	0.086	4.750	0.187	4.750	0.187	4.800	0.160
12	4.667	0.222	4.125	0.359	4.250	0.521	4.000	0.400
13	4.619	0.236	4.375	0.234	4.000	0.667	3.500	1.050
14	3.810	0.726	4.250	0.437	3.750	0.854	4.000	0.800
15	4.190	0.440	3.875	0.359	3.333	0.389	3.800	0.760

FIGURE 3

SUPPORT FOR INCLUSION OF SPECIFIC CONTENT COMPONENTS IN A CANADIAN CONTEXT FOR SCIENCE EDUCATION BY PRACTICING SCIENCE TEACHERS

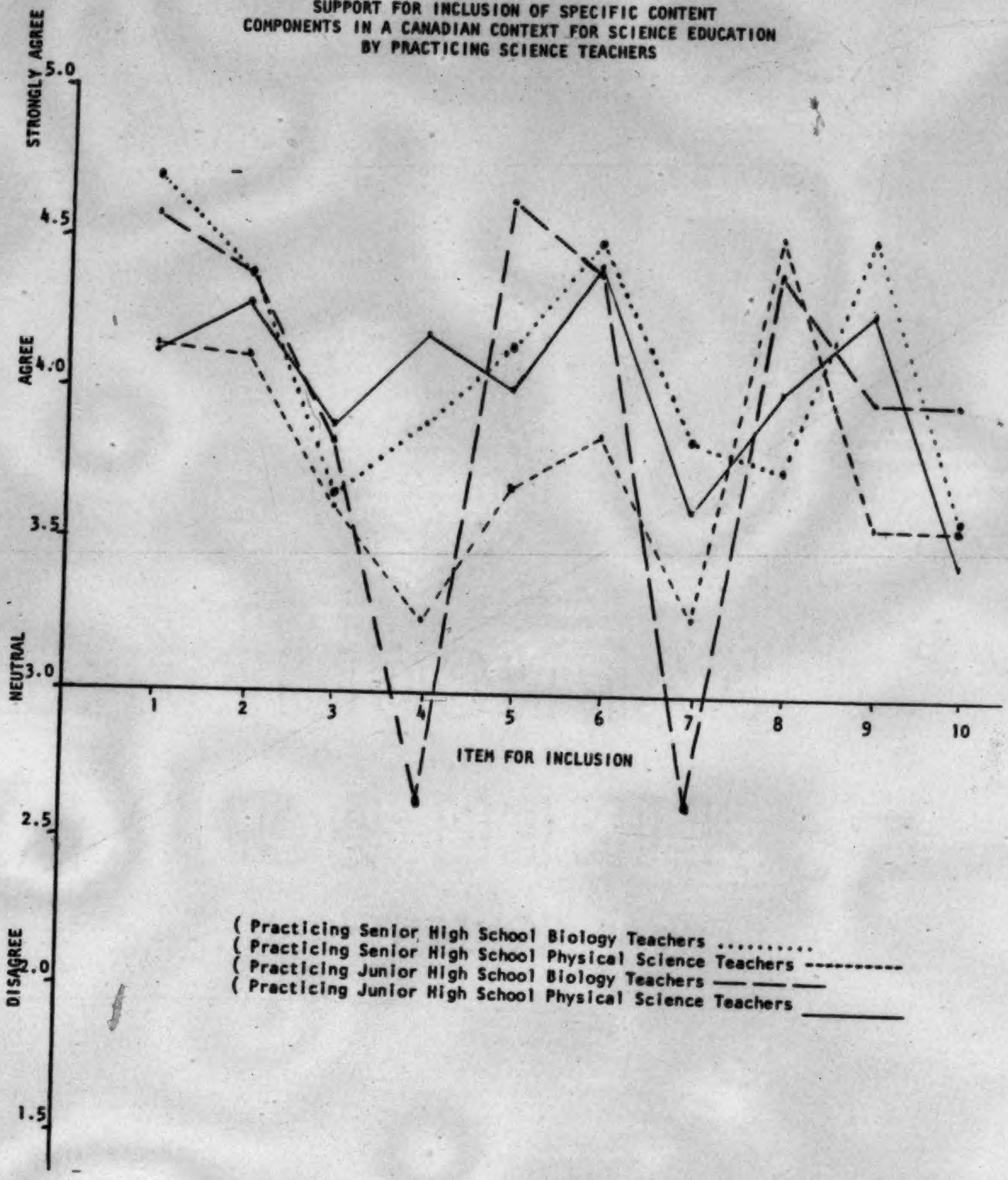
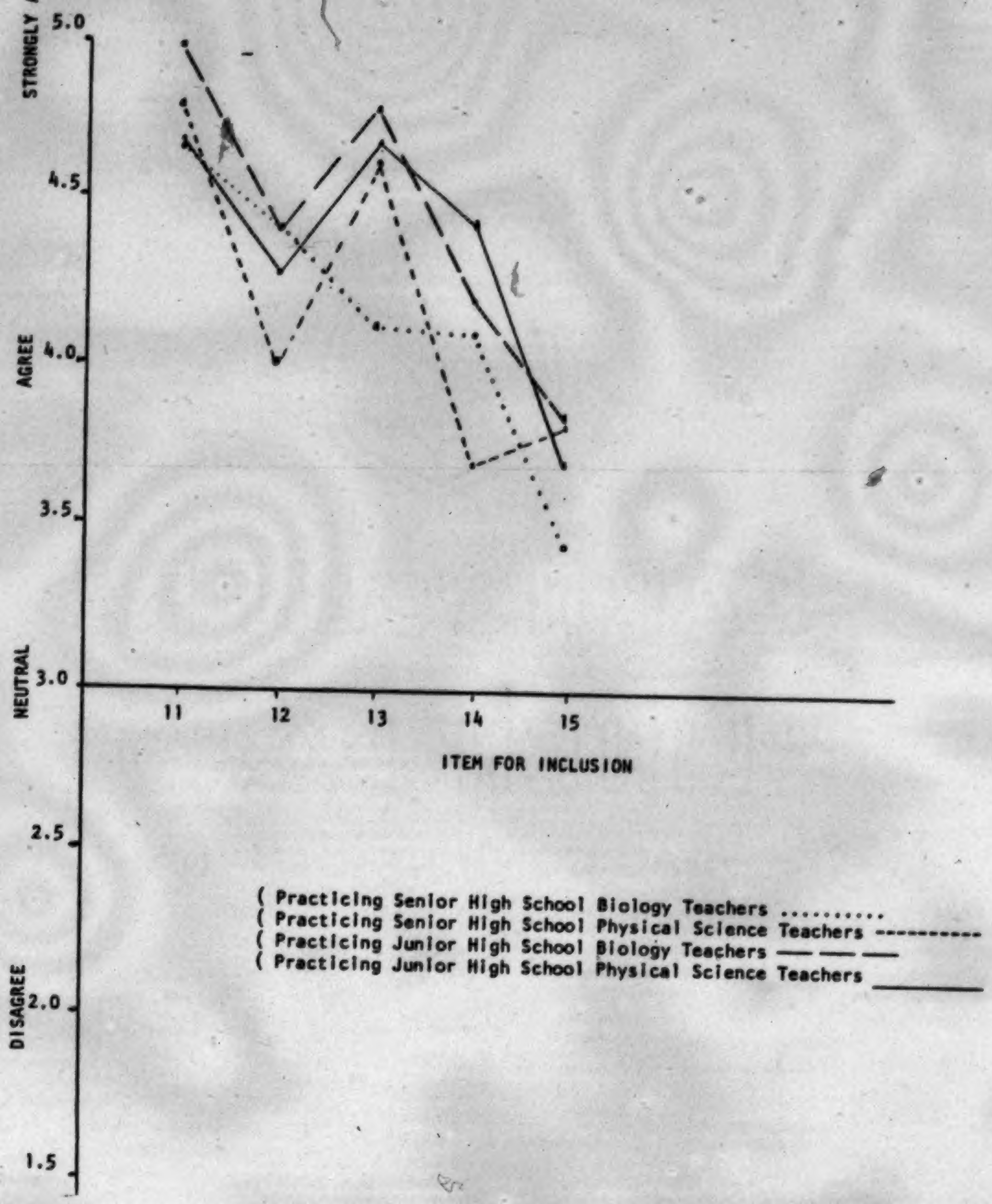


FIGURE 4

SUPPORT FOR INCLUSION OF SPECIFIC METHODOLOGICAL COMPONENTS
IN A CANADIAN CONTEXT FOR SCIENCE EDUCATION
BY PRACTICING SCIENCE TEACHERS



biology teachers indicated (with identical mean score ratings of 2.60) disagreement to inclusion of items:

(4) History of Canadian science which includes the impact that science and technology had historically upon Canadian life.

(7) A knowledge of the tradition in which science is done in Canada including present emphasis and philosophy underlying Canadian science.

Both of these items were supported by the other three practicing science teacher groups, with mean support scores ranging from 3.25 to 3.80 for item number 7 and from 3.25 to 4.14 for item number 4. Item numbers 4 and 7 were also found to be the least reliable with mean score ranges of 2.60 to 4.14 and 2.60 to 3.80 respectively.

The most reliable items were identified as:

(2) Promotion of an understanding and appreciation of the relationship between science and Canadian society including the impact that science and technology have on Canadian society and culture today (mean score range 4.08 to 4.40).

(3) A depiction of how science and technology can be used to alter the economic and political situation in Canada (mean score range 3.67 to 3.86).

(11) Maximum use of the local environment through experiences and examples using the immediate natural and social world in which the student lives (mean score range 4.70 to 5.00).

(12) Inclusion of topics and problems of current local scientific significance which could include taking feasible action on suggested solutions (mean score range 4.00 to 4.40).

The most support was again indicated for item:

(11) Maximum use of the local environment through experiences and examples using the immediate natural and social world in which the student lives (mean score range 4.70 to 5.0).

This high support of item 11 at the "strongly agree" (5.0) level was registered by the practicing junior high school biology teachers who were, as shown in Table 11, unanimous in their support of this item recording a variance of 0.000.

Another example of extreme variance is recorded for the practicing senior high physical science teachers with regard to item number 14: "Provision for teacher's guides to show how foreign instructional materials can be used or supplemented to be considered more in line with Canadian educational circumstances and needs." Though their mean score support was 3.667, the variance recorded was 2.056. Other items recording a high degree of within-group variance for all four groups were:

(3) A depiction of how science and technology can be used to alter the economic and political situation in Canada (variances of 1.210, 0.556, 1.360, 0.980).

(8) Acknowledgement of the interrelationship of pure and applied science allowing a description of the world as it is while also showing the means by which the environment is adapted to suit man's needs (variances of 0.810, 0.417, 0.640, 1.143).

(15) A method for bringing the unique problems of each of the major regional areas in Canada together into one context interrelated through common concerns (variances of 0.810, 0.639, 0.960, 0.816).

TABLE 11

Comparison of Variance Within Groups of Practicing Science Teachers for Support of Elements in Stage V

Questionnaire Item Number (element)	Identified Group of Practicing Teachers in							
	Senior High School Biology		Senior High Physical Science		Junior High School Biology		Junior High Physical Science	
	Mean Score $\overline{X}$	Variance S^2	Mean Score $\overline{X}$	Variance S^2	Mean Score $\overline{X}$	Variance S^2	Mean Score $\overline{X}$	Variance S^2
1	4.700	0.410	4.167	1.472	4.600	0.240	4.143	0.408
2	4.400	0.840	4.083	0.243	4.400	0.240	4.286	0.204
3	3.700	1.210	3.667	0.556	3.800	1.360	3.857	0.980
4	3.900	1.090	3.250	0.687	2.600	0.640	4.143	0.122
5	4.100	0.690	3.667	0.889	4.600	0.240	4.000	0.286
6	4.500	0.250	3.833	0.472	4.400	0.240	4.429	0.245
7	3.800	0.960	3.250	0.854	2.600	0.240	3.571	0.245
8	3.700	0.810	4.500	0.417	4.400	0.640	4.000	1.143
9	4.500	0.450	3.583	1.076	4.000	0.400	4.286	0.490
10	3.600	0.440	3.583	0.910	4.000	0.800	3.429	0.531
11	4.700	0.210	4.833	0.139	5.000	0.000	4.714	0.204
12	4.400	0.440	4.000	0.500	4.400	0.240	4.286	0.204
13	4.200	0.560	4.667	0.222	4.800	0.160	4.714	0.204
14	4.100	0.490	3.667	2.056	4.200	0.160	4.429	0.245
15	3.700	0.810	3.833	0.639	3.800	0.960	3.429	0.816

Combining both the support of the elements expressed by the prospective science teachers and the practicing science teachers in the sample, it becomes evident that the most support for a particular element within the clue structure of a Canadian context for science education is for item:

(11) Maximum use of the local environment through experiences and examples using the immediate natural and social world in which the student lives.

With the exception of elements 4 and 7 not supported strongly by the practicing junior high school biology teachers, each of the other elements in the questionnaire were supported by all practicing teacher groups.

The statistical analysis of the questionnaire data gives support to the clue structure elements for a Canadian context for science education, hence according to Doran (1980) establishes a degree of validity for the questionnaire.

Identification of Common Variables

The next data to be analyzed included both the 51 prospective teachers and the 34 practicing science teachers who took part in the study. Factor analysis using principal axes with iteration as the method of factoring and varimax rotation was used to identify the variables included in the given elements. Examination of the pattern on primaries resulting from the factor analysis and illustrated in Table 12, identifies 6 variables which include the following elements.

TABLE 12

Results of Factor Analysis of Stage V Data

Questionnaire Item	Communalities H**2	Variable 1	2	3	4	5	6
1	0.457	-0.028	-0.143	0.105	0.583	0.108	0.164
2	0.844	-0.074	0.080	0.012	0.900	0.016	-0.013
3	0.608	0.712	0.230	-0.360	0.111	-0.050	0.036
4	0.653	-0.058	0.771	0.073	-0.040	-0.053	0.132
5	0.696	0.386	0.022	-0.157	0.058	0.148	0.563
6	0.595	-0.089	0.220	0.289	0.127	-0.103	0.479
7	0.658	-0.012	0.859	-0.065	-0.033	0.064	-0.037
8	0.648	0.840	-0.203	0.254	-0.001	-0.180	-0.064
9	0.600	0.025	0.402	0.299	0.108	-0.184	0.055
10	0.465	0.617	0.048	0.072	-0.247	0.050	0.208
11	0.762	0.541	-0.090	0.306	0.073	0.211	-0.008
12	0.605	-0.034	0.173	0.628	-0.147	0.271	-0.021
13	0.500	-0.004	-0.074	0.631	0.179	-0.041	0.060
14	0.597	-0.109	-0.056	0.066	0.081	0.762	0.058
15	0.470	0.147	0.255	0.173	0.159	0.230	-0.188
	% COM VAR.	24.324	20.927	17.897	16.272	10.527	10.054
	% TOT VAR.	24.467	21.050	18.001	16.367	10.589	10.113

% TOT VAR identifies the percentage of variance accounted for by each factor of the amount entered into the diagonals of the matrix factored at the last factoring iteration.

% COM VAR identifies the percentage of common variance accounted for by each factor. This value is the sum of squares of each factor divided by the total variance accounted by all factors.

Variable 1:

Item 3. A depiction of how science and technology can be used to alter the economic and political situation in Canada.

Item 8. Acknowledgement of the interrelationship of pure and applied science allowing a description of the world as it is while also showing the means by which the environment is adapted to suit man's needs.

Item 10. A treatment of Canadian science policy promoting an understanding and awareness of the differential emphasis on certain areas of research in pure and applied science in Canada.

Item 11. Maximum use of the local environment through experiences and examples using the immediate natural and social world in which the student lives.

Variable 2:

Item 4. History of Canadian science which includes the impact that science and technology had historically upon Canadian life.

Item 7. A knowledge of the tradition in which science is done in Canada including present emphasis and philosophy underlying Canadian science.

Item 9. Attention to methods of inquiry which can be used in dealing with pressing Canadian problems which require a scientific/technological solution.

Item 15. A method for bringing the unique problems of each of the major regional areas in Canada together into one context interrelated through common concerns.

Variable 3:

Item 12. Inclusion of topics and problems of current local scientific significance which could include taking feasible action on suggested solutions.

Item 13. Inclusion of Canadian produced science instructional materials which students may easily relate to their own life and environment.

Variable 4:

Item 1. An interdisciplinary approach to science facilitating study of man's interrelatedness with his natural and social environment.

Item 2. Promotion of an understanding and appreciation of the relationship between science and Canadian society including the impact that science and technology have on Canadian society and culture today.

Variable 5:

Item 14. Provision for teacher's guides to show how foreign instructional materials can be used or supplemented to be considered more in line with Canadian educational circumstances and needs.

Variable 6:

Item 5. Promotion of an awareness of the role of Canadian scientists and technologists in Canada's growth and development.

Item 6. Recognition of contributions made by Canadian scientists to international science.

Since the communalities are greater than .2, this indicates that the items are within the space defined by the number of variables selected. Each of the factors have been identified by the items which have "high" loadings on a variable. These have been clustered together on common variables.

Identification of these common factors opens new doors for further research into the area of a Canadian context for science education which will not be pursued any further in this study. The results of factoring items produces the most difficulty in factor interpretation. Items are very limited measures, particularly if the instrument is not refined through several iterations. Therefore, it was the purpose of this portion of the study to identify the presence of existing relationships between elements of the clue structure which were used as items in the questionnaire to allow a better understanding of the clue structure itself.

Relationships Between Perceptions of Prospective Science Teachers

The data from the 51 prospective science teachers was subjected to One-way Multivariate Analysis of Variance and Covariance and used to test the related null hypotheses 1 and 2, Ho_1 and Ho_2 respectively. These null hypotheses also comprise related research which may further illustrate the perceptions of a Canadian context for science education.

Ho_1 states: "There is no difference in support of elements to be included in a Canadian context for science education by prospective biology teachers, prospective physical science teachers, prospective elementary science teachers, or prospective environmental education teachers". The results of the multivariate analysis of variance and covariance are presented in Table 13. On the basis of the results presented in Table 13, Hypothesis 1 is rejected. At an alpha level of 0.05, significant differences occurred between the prospective biology science teachers and prospective environmental teachers as well as between prospective physical science teachers and prospective environmental education teachers. This suggests there is a difference in prospective science teacher groups' perceptions toward a Canadian context in science education prior to gaining extensive classroom experience. The prospective environmental science teachers require a much broader subject matter background, which may have been a factor in distinguishing this group from the others. There was no significant difference in perceptions of the other three prospective science groups.

Ho_2 states: "There is no difference in perception by the four groups of prospective science teachers for inclusion of elements in a Canadian context as represented by the variables identified in factor analysis". Using M matrix contrasts with the MANCOVA program used to test Hypothesis 1, the results in Table 14 were obtained. This table shows the differences found between support for each variable (as identified by Factor Analysis) by each group when an alpha level of 0.05 is set. On the basis of the results in Table 14, which indicates that the probabilities for all 6 variables range about the acceptable alpha level of 0.05 for significance, Hypothesis 2 is rejected. This suggests that there is a difference in perception by the four prospective science teacher groups towards inclusion of each of the variables and supports the findings related to Hypothesis 1.

TABLE 13

Contrasts Between Prospective Science Teacher Groups in Stage V (α=.05)

Groups (Prospective Teachers)	*DF1	DF2	F-Ratio	Probability	Significant Level
biology vs. elementary	15.0	33.0	0.917	0.555	NO
biology vs. phys. science	15.0	33.0	1.218	0.307	NO
biology vs. environmentsl	15.0	33.0	3.232	0.002	YES
elementary vs. phys. science	15.0	33.0	0.770	0.699	NO
elementary vs. environmental	15.0	33.0	1.074	0.414	NO
phys. science vs. environmental	15.0	33.0	2.732	0.008	YES

*DF1 refers to degrees of freedom.

TABLE 14

Perceptions of Prospective Science Teachers for Inclusion of Variables in Stage V
($\alpha = .05$)

Variable	*DF1	DF2	F-Ratio	Probability	Significant Level
1	3.0	47.0	0.695	0.050	YES
2	3.0	47.0	2.700	0.050	YES
3	3.0	47.0	5.753	0.049	YES
4	3.0	47.0	3.456	0.049	YES
5	3.0	47.0	0.645	0.050	YES
6	3.0	47.0	0.816	0.050	YES

*DF1 refers to degrees of freedom.

Comparison of Science Teachers' Perceptions of Canadian Context for Science Education

When multivariate analysis was carried out on the responses of the 85 participants which included the practicing teachers, the probability of the differences occurring between the identified science teaching groups by chance was established as an alpha level of 0.05. Multivariate analysis of variance and covariance was then used to test the remaining related research Hypotheses 3 to 7. The results of this analysis are presented in Table 15.

Ho_3 states: "There is no difference in perception of elements to be included in a Canadian context for science education by prospective biology teachers and practicing senior high school biology teachers". On the basis of the results presented in Table 15 Hypothesis 3 is accepted.

Ho_4 states: "There is no difference in perception of elements to be included in a Canadian context for science education by prospective physical science teachers and practicing senior high school physical science teachers". On the basis of the results presented in Table 15 which indicates a significant level was not reached, Hypothesis 4 is accepted.

Ho_5 states: "There is no difference in perception of elements to be included in a Canadian context for science education by prospective physical science teachers and practicing junior high physical science teachers". Once again, on the basis of the results presented in Table 15, which indicates significance was not present, Hypothesis 5 is accepted.

TABLE 15

Contrasts Between Teacher Groups in Stage V (α=.05)

Teacher Groups Compared	*DF1	DF2	F-Ratio	Probability	Significant Level
prosp. biology vs. jr. high biology	15.0	63.0	2.135	0.019	YES
prosp. biology vs. sr. high biology	15.0	63.0	1.585	0.104	NO
jr. high biology vs. sr. high biology	15.0	63.0	1.345	0.203	NO
prosp. physical vs. jr. high physical	15.0	63.0	0.792	0.682	NO
prosp. physical vs. sr. high physical	15.0	63.0	1.480	0.140	NO
jr. high physical vs. sr. high physical	15.0	63.0	1.382	0.184	NO
jr. high biology vs. jr. high physical	15.0	63.0	1.480	0.140	NO
sr. high biology vs. sr. high physical	15.0	63.0	1.917	0.038	YES

*DF1 refers to degrees of freedom.

Ho_6 states: "There is no difference in perception of elements to be included in a Canadian context for science education by prospective biology teachers and practicing junior high school biology teachers". Table 15 indicates that the probability level of 0.019 is significant at an alpha level of 0.05. Therefore, on the basis of these results, Hypothesis 6 is rejected. This suggests that there are significant differences in the perceptions of elements for inclusion in a Canadian context for science education between prospective biology teachers and junior high school biology teachers. As mentioned previously, the size of the sample of junior high school biology teachers may have an effect on this result.

Ho_7 states: "There is no difference in perception of elements to be included in a Canadian context for science education by junior high school biology teachers, junior high school physical science teachers, senior high school biology teachers, and senior high school physical science teachers". The results of this comparison are illustrated by four comparisons in Table 15. The first, between junior high school biology teachers and senior high school biology teachers did not reach a significant level with a probability of 0.203. The second comparison, between junior high school physical science teachers and senior high school physical science teachers was not significant with a probability of 0.184. The third contrast, between junior high school biology and junior high school physical science teachers revealed no significant difference with a probability of 0.140. The fourth comparison, between senior high school biology teachers and senior high school physical science teachers produced a significant result with a probability of 0.038. On the basis of these results, Hypothesis 7 is rejected. This suggests that though no differences appeared between junior high school science teachers or their respective disciplines in senior high school, there is a significant difference in the perception of elements to be included in a Canadian context between physical science and biology teachers at a senior high school level.

In summary, it was found that Hypotheses 1, 2, 6 and 7 were rejected while 3, 4 and 5 were accepted. In essence, this means that significant differences in support were found among some of the prospective teacher groups and among some of the practicing teacher groups of the elements to be included in a Canadian context for science education. However, in the main there were no significant differences in this support when the perceptions of prospective teachers were compared with those of practicing teachers.

Discussion of Results

The five stage design of this study proved to be adequate in developing an acceptable theoretical perspective and clue structure for a Canadian context for science education. However, there are some reservations regarding the difference between expected and actual usefulness of each stage. The first stage, the draft of the theoretical perspective proceeded very much along the lines expected. The literature research provided a wealth of useful information to treat by informal analysis. Much of this literature was polemical and nationalistic in tone and inadvertently the researcher reflected this tone in the initial draft of the perspective. Owing to insufficient familiarity with the topic, there was also a tendency to be insufficiently critical and integrative of the available information when writing the initial draft.

The validation of the initial draft of the theoretical perspective in the second stage did not provide the anticipated feedback. Much of the limited response debated the issue of whether a Canadian context for science education was a "good" or necessary context. Some of the validators were interpreting the purpose of a Canadian context to be a replacement of other contexts of science already being used, rather than inclusion with the other contexts. Obviously, this aspect of the perspective required clarification. Unfortunately, the validators did not react critically to all of the major content and methodological components of the theoretical perspective. The initial validation did assist in removing the nationalistic and polemic tone of the theoretical perspective and communicated the need to shorten the document.

The revision of the initial draft in Stage III resulted in a much improved theoretical perspective for Canadian context in science education. This opinion was expressed by those Stage IV validators who had also been Stage II validators.

The validation by the national sample of science educators, science teachers, scientists, science historians and philosophers was certainly a key stage in the design of the study. Due to the expense of mailing such a document to individuals across Canada, it was not feasible to select more than 120 validators. In particular, it would have been of great value to the study to increase the number of science teachers from across Canada.

The number of responses from national validators across Canada was not as large as anticipated. However, the quality of responses and amount of effort put into the responses far exceeded expectations. These validators are listed in the acknowledgements and their efforts are greatly appreciated. The validation in Stage IV provided strong indications of which elements are most favoured for inclusion in a Canadian context for science education and what the controversial areas are. This validation will be of help in developing a more rigorous clue structure for analyzing science instructional materials for Canadian context.

The Stage V validation was not as successful as was initially hoped owing to such factors as limited sampling, size of the sample and low response rate from some of the science teacher groups. Further research in this area needs to be done to include a similar validation of the clue structure using a much larger sample of classroom teachers, and one with representation from a much larger geographic area--possibly on a national sclae. The validation did help the study by providing an indication of which elements for inclusion in a Canadian context for science education were most favoured by science teachers. It was also interesting to learn that significant differences exist between science teacher groups from differing disciplines and with differing classroom experience.

Basically, the theoretical perspective/clue structure model used seems to be a useful one for identifying a Canadian context for science education. The ease with which it was possible to extract a clue structure from the theoretical perspective was very gratifying.

This version of the clue structure will be of considerable value in future efforts to assess science curriculum materials for Canadian context. Obviously, further refinement of this clue structure will emerge from its application in the curriculum area.

At this point a comparison of the reaction of the three validation groups seems in order. A concern that emerged in all three validations was the nationalism that was implicit in the notion of Canadian context. However, "Canadianism" seemed acceptable if it meant that science and technology was viewed as showing their value to all people by applying them first of all to the local setting. If nationalism is defined as the doctrine that national interests, security, etc. are more important than international consideration then it is a human foible to be cautious of. Inversely, if nationalism refers to national quality or character, that is what distinguishes Canadian society and culture from others then it must be considered as an integral component of a Canadian context for science education.

The issue of nationalism versus internationalism in science was a controversial one for all three groups of validators. An inherent misunderstanding of the theoretical perspective may have been responsible for some of the criticism, for the perspective in fact projected a middle road on this matter, which was understood by some of the validators as is illustrated by the following comment: "Ensuring a sense of internationalism combined with one of nationalism is a very important positive feature".

Since the first validation group did not focus on very many specific components of the theoretical structure the remaining discussion will involve only the last two validation groups. Perhaps, it would be easiest to deal with this comparison on the basis of the elements of the clue structure. There seems to be a significant correlation between the elements favored by prospective and practicing teachers with elements 1, 11, and 13 common to both. There is a very high correlation between elements least favored by prospective and practicing science teachers with elements 4, 7, and 10 common to both. A significant correlation also seems to exist between the most supported elements chosen by the national validators and the science teacher groups with only one new element, 9 (attention to inquiry), differing. The same holds true for elements least supported, with elements 7 and 10 common to all three.

Element 11, maximum use of the local environment through experiences and examples using the immediate natural and social world in which the student lives, was strongly supported by all three validation groups. Two out of three groups showed strong support for the elements, 8, 12, and 13 which focused respectively on the interdisciplinary approach to science teaching, interrelationship of pure and applied science, inclusion topics and problems of local interest, and use of Canadian science instructional materials.

It would appear that the elements most favored are those which suggest relevant application of science to the students' immediate environment and show the interrelationship of science and society. This may be the result of the recent realization of those involved in science education that there is a distinct need to relate science to the students' immediate world and show them the relevance of science through emphasis of the science-society interaction. It may also be noted that each of these implies Canadian, yet the selection for inclusion of these elements in instructional materials may be based on necessity to use the most relevant example rather than an association with a national identity.

Elements 7 (a knowledge of the tradition in which science is done in Canada inclusing present emphasis and philosophy underlying Canadian science) and element 10 (a treatment of Canadian science policy promoting an understanding and awareness of the differential emphasis on certain areas of research in pure and applied science in Canada) were least supported by all three validating groups. There seem to be various reasons for this. First, many believe that such a policy or philosophy does not exist. Second, it would appear that many science educators regard "Canadian" in the same manner as "nationalism", with the implication that national interests are more important than international consideration. They seem to, therefore, shy away from any association with elements which may be perceived in a nationalistic manner. Also, the negative reaction of some of the validators to Canadianism may be rooted in a misconception that the theoretical perspective advocated the exclusion of others. The clue structure which has been developed in this study does not do that since it does not address elements other than those of a Canadian context. That is, this study does not ask for removal of other contexts--only the inclusion of a Canadian one.

There was poor support for inclusion in the science curriculum elements which reflect Canadian traditions, goals, philosophy and policy in science. Indeed, the science teachers in Stage V gave least support to element 4 of the clue structure which focuses on the history of Canadian science. One of the reasons for this attitude may be ignorance on the part of most of the validators in the Stage II and V validations of the history and current practice of Canadian science. For this some of the blame must rest on the incomplete education of science teachers; teacher education programs normally give little or no attention to this area of science, let alone Canadian science. Of course, there were quite a few comments made by both validator groups about their priorities in science instruction, namely to dispense the conceptual content of the science disciplines.

In the statistical analysis, the clustering of elements identified by the factor analysis did not assist in identification of the general relationships existing between elements of the clue structure or their support of the validators. The clustering from the factor analysis is based on the relationships of the support given elements by each of the Stage V validators. Since each of the elements of the clue structure is a separate item or component and able to stand alone, meaningful clustering is difficult.

The multivariate analysis revealed that there were both commonalities and significant differences in support of elements to be included in a Canadian context for science education by prospective and practicing teachers. While these differences are interesting and may be representative of perceptions of Canadian context of larger, random samples, at this point it is unwarranted to generalize. Further validation of the clue structure is essential in order to establish if indeed training, teaching experience, conditions of teaching and so forth do have an impact on teacher perceptions of Canadian context for science education.

In conclusion, it can be said that whatever the shortcomings are of the theoretical perspective and the inherent clue structure, substantial progress was made in identifying a Canadian context for science education. It would be possible to revise the perspective document, but to what purpose? The criticisms made of both the perspective and the clue structure were not unanimously held by validators, nor do they necessarily question the validity of any of the elements projected for a Canadian context for science education. Therefore, the most productive step to take next is to test the value of the clue structure in analyzing instructional materials for Canadian context.

CHAPTER V

Summary and Conclusions

Introduction

In this chapter a brief summary of the study will be presented. It will be followed by conclusions of the researcher with respect to the development of the theoretical perspective and clue structure for determining a Canadian context in science education. It will also include conclusions of the researcher to reject or hold tenable the associated research hypotheses. During the course of the study, it became evident that many other aspects of the area of study required further investigation. These areas of research will be outlined in the final part of the chapter as recommendations for further research.

Summary

The study was designed to develop a theoretical perspective and subsequent clue structure based on Roberts and Russell's (1975) analytical structure which accurately describes a Canadian context for science education and can be used to determine the extent to which instructional materials used in science teaching in Canada reflect a Canadian context. Development of the theoretical perspective and clue structure with appropriate validation of each phase was accomplished in five stages. In Stage I an initial draft of a theoretical perspective for a Canadian context in science education was developed based on an informal analysis of information obtained from an extensive search of the science, science education, education, and Canadian cultural literature. In Stage II reaction to this initial theoretical perspective by a limited sample of 20 science educators and science graduate students at the University of Alberta was obtained, both in the form of written response and oral reaction session. The main gist of this reaction was that the theoretical perspective reflected a too nationalistic and polemical stance and that it was in need of substantial clarification of terminology and ideas.

In Stage III, on the basis of the Stage II reaction and further literature research and informal analysis, a revised edition of the theoretical perspective was prepared.

Stage IV involved the validation of the revised theoretical perspective by a national sample of 120 validators. Attempts were made to have a representative sample with regard to geographical distribution and distribution among those individuals integrally involved or affiliated with science education in Canada. Although only 44 validators (36.7 percent of the total sample) responded, a vast amount of written reaction was obtained. Several major ideas were emphasized by the validators. First, a high level of support was noted for the theoretical perspective. Second, a great deal of controversy surrounded the issues of national identity and the national versus international views of science. The best supported view seemed to be that Canadianization of science education should not be carried out for "nationalistic" reasons but simply because science and technology can best show their value if they are applied first of all in the local setting in which the teaching is carried out. Third, there was support for inclusion of technology in science education, stressing the interrelationship of pure and applied science; inclusion of the science-society interaction; and maximum use in science teaching of the local environment and applications of science to the students' immediate environment.

In Stage V the elements of a clue structure were identified in the revised theoretical perspective. A total of 15 elements were identified, ten of which were content and five were methodological in nature as perceived in terms of a science curriculum which would adequately reflect a Canadian context for science education. The content elements focused on interdisciplinary studies, science-Canadian society interaction, science-technology relationship, history of Canadian science and technology, contributions of Canadian scientists, Canadian scientific tradition, methods of inquiry inherent in Canadian science, and Canadian science policy. The methodological components focused on the use of the local environment in science courses, relevant and topical issues in science, use of instructional materials in Canada, guidelines for adapting foreign instructional materials, and integration of local, regional and national concerns in science education.

Validation of the clue structure was sought through the use of a survey questionnaire. The sample was composed of 8 different science teacher groups, of which 4 were prospective science teachers and 4 were practicing teachers. The sample consisted of 128 teachers of which 85 or 66.4 percent participated. Using a Likert scale teachers were asked to indicate level of agreement with each of the 15 elements for inclusion in teaching science in a Canadian context.

In addition, open-ended reaction to the clue structure was solicited. The data collected in Stage V were first subjected to statistical analysis to determine degree of support for the clue structure elements by the prospective and practicing science teachers. Analysis was extended also to an opinion element which was included in the questionnaire to measure the support for the clue structure elements as a unit. Substantial support was expressed for the clue structure both in the formal and open-ended responses. The main findings of this validation process of the clue structure are expressed in seven null hypotheses. The summary of these findings is given in Table 16. In essence, significant differences in support were found among some of the prospective teacher groups and among some of the practicing teacher groups of elements to be included in a Canadian context for science education. However, in the main there were no significant differences in this support when the perceptions of prospective teachers were compared with those of practicing teachers. Reasons for differences in support may be attributable to differences in science area and grade level taught, teacher training, teaching experience and the sampling technique employed.

Conclusions

The study showed that an acceptable theoretical perspective and clue structure for a Canadian context in science education can be formulated. This outcome vindicated the use of the model by Roberts and Russell (1975) as a basis for developing the theoretical perspective. The considerable support given by all three validator groups to the theoretical perspective and clue structure was gratifying.

TABLE 16

Summary of Decision Mode Concerning Associated Hypotheses in Validation of the Clue Structure

Hypothesis	Decision Tenable	Decision Reject
Ho_1: There is no difference in support of elements to be included in a Canadian context for science education by prospective biology teachers, prospective physical science teachers, prospective elementary science teachers or prospective environmental education teachers		X
Ho_2: There is no difference in perception by the four groups of prospective science teachers for inclusion of elements in a Canadian context as represented by the variables identified in factor analysis		X
Ho_3: There is no difference in perception of elements to be included in a Canadian context for science education by prospective biology teachers and practicing senior high school biology teachers	X	
Ho_4: There is no difference in perception of elements to be included in a Canadian context for science education by prospective physical science teachers and practicing senior high school physical science teachers	X	
Ho_5: There is no difference in perception of elements to be included in a Canadian context for science education by prospective physical science teachers and practicing junior high physical science teachers	X	
Ho_6: There is no difference in perception of elements to be included in a Canadian context for science education by prospective biology teachers and practicing junior high school biology teachers		X
Ho_7: There is no difference in perception of elements to be included in a Canadian context for science education by junior high school biology teachers, junior high school physical science teachers, senior high school biology teachers, and senior high school physical science teachers.		X

It underlines the need to push vigorously for inclusion of a rational Canadian context in science education in this country. The reaction of the skeptics and dissenters is also appreciated a great deal because they helped in a multitude of ways to clarify the researcher's conception of a Canadian context for science education.

The researcher recognizes that his theoretical perspective and concomitant clue structure is only one of several that are possible. In addition, the validation of the perspective and clue structure is biased by the samples of validators chosen. Notwithstanding these limitations of the study, the stage has been set for a follow-up study in which the theoretical perspective via the clue structure can be tested and revised further by assessing selected instructional materials in science for Canadian context.

Recommendations for Further Research

As the study was being conducted, it became apparent to the investigator that a number of other areas related to the study needed further investigation:

(1) A primary extension of this study would be to actually use the clue structure in the analysis of science instructional materials presently being used in science classrooms. The main purpose of this analysis would not be to pass judgment on the adequacy of the materials selected for Canadian context, but to test the applicability of the clue structure for identifying and analyzing Canadian context in selected science instructional materials. However, this analysis would indicate deficiencies of Canadian context in the materials which then could be rectified.

2. The clue structure should be refined and expanded on the basis of the feedback from the national validation of the theoretical perspective and the questionnaire. A more rigorous validation of the clue structure is required, using an appropriate national sample.

3. It may be instructive to further investigate and define the six latent variables influencing the clue structure whose existence was detected in this study.

4. The theoretical perspective and the concomitant clue structure should be tested for its value in guiding the development of new science courses with a heavy focus on Canadian context.

5. It should be possible to use the theoretical perspective and clue structure to do a longitudinal comparative study of the extent of Canadian context in science instructional materials. Specifically, this would entail analysis for Canadian context of selected textbooks in a given course currently used, with those used say 10, 20 and 30 years ago.

6. It should be possible to use the theoretical perspective and clue structure in a comparative study in which equivalent instructional materials produced in two different countries (e.g., Canada and the U.S.A.) are compared for "national" context. If this was done on a sufficient scale, the study would reveal whether science educators in other countries indeed pay more attention to national context than is given to Canadian context in Canada.

7. What would be the result of administering the theoretical perspective or the Stage V questionnaire in the United States, changing the word Canadian to American? Would the question of national identity, with emphasis on history, philosophy, or policy of science

be treated differently?

8. Using the clue structure it should be possible to assess the extent of improvement of Canadian context in Canadian revisions of foreign instructional materials in science.

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APPENDIX I

Outline of

Stage I Version of

A THEORETICAL PERSPECTIVE FOR 'A CANADIAN CONTEXT FOR SCIENCE EDUCATION'

I. Introduction
- A. Frame of Reference

II. Elements of a Canadian Context
- A. The Identity Crisis
- B. Identity Crisis in Science in Canada
- C. Effect of the Identity Crisis on Canadian Science Education
- D. A Case for Canadian Context in Science Education

III. Definition of Theoretical Perspectives for a Canadian Context for Science Education
- A. Underlying Considerations
- B. Elements of a Theoretical Perspective
  - 1. Content Components
    - (a) Interdisciplinary Approach
    - (b) Science-society Interaction
    - (c) History of Canadian Science
    - (d) Philosophy Underlying Canadian Science
    - (e) Applied and Pure Science and Their Interrelationship
    - (f) Science as Inquiry
    - (g) Science Policy, Current Research Emphasis and Their Interaction

2. Methodological Components
    (a) Maximum Use of Local Environment
    (b) More Canadian Written Textbooks and Instructional Materials
    (c) Policy on Adaptation of Foreign Instructional Material to Canadian Context
    (d) Handling Problems of Regionalism

IV. Implications of a Theoretical Perspective on Canadian Context for Science Education
  A. For Curriculum Development, Implementation and Evaluation
  B. For Curriculum Decision Making

V. Conclusion

APPENDIX II

Stage II Reactions to Initial Draft of A Theoretical Perspective for 'A Canadian Context for Science Education'

Included in this Appendix are:

(1) A covering letter from the researcher to science educators and science education graduate students at the University of Alberta;

(2) An invitation to a reaction session to discuss the theoretical perspective;

(3) Combined reactions from respondents.

November 3, 1981

Fellow Science Educators,

A Theoretical Perspective for 'A Canadian Context for Science Education' is the basis of a clue structure which I am devising as part of my M.Ed. thesis. In order for the theoretical perspective to serve as a foundation from which to examine instructional materials to determine if a Canadian context has been included, it must give a clear indication of what Canadian context is. This perspective is only one of the unlimited number of views possible. It does however, serve as a perspective from which to analyze science education in Canada. There is no attempt to come to a consensus on the definition of Canadian context.

In order for this perspective to reflect a realistic view of a Canadian context for science education, this pilot study will solicit reactions to the theoretical perspective from science educators at the University of Alberta. After analyzing the reactions and making any changes which seem warranted based on these reactions, the theoretical perspective will be sent across Canada to selected science educators and scientists who will be asked to react to the theoretical perspective. All contributors will be acknowledged in the thesis, both from the pilot and major reaction.

In reacting to this perspective, feel free to use the wider left-hand margin to make comments throughout the paper, or to give a comprehensive reaction at the end of the perspective (on the back of the paper), or both.

I would appreciate knowing your contentions, support, notes or errors or omissions, need for additions, etc.

To enable a November mailing across Canada, please return your copy of the theoretical perspective with your comments to my mailbox by Thursday, November 12, 1981.

Thank you for your participation and valuable input.

Gratefully yours,

Rick Mrazek

Rick Mrazek

MEMBERS OF ED. C.I. 570 AND OTHER SCIENCE EDUCATORS

YOU ARE INVITED TO A

REACTION SESSION

TO DISCUSS

A THEORETICAL PERSPECTIVE FOR 'A CANADIAN CONTEXT FOR SCIENCE EDUCATION'

TO BE HELD

FRIDAY, NOVEMBER 6 AT 2:30 P.M.

IN ROOM 359

Discussion to be continued at Power Plant following
the formal session.

Copies of the Theoretical Perspective will be distributed Tuesday, November 3. Check your mailbox. Your participation would be appreciated for your opinions and reactions may be extremely helpful.

Combined Stage II Reactions to Stage I Version of A Theoretical Perspective for 'A Canadian Context for Science Education'

The following reactions are those of science education graduate students and science educators at the University of Alberta to the Stage I version of the theoretical perspective. Their comments and concerns are listed randomly, due to the nature of the reaction session from which a number of these were noted. The nature of the comments tended to be singularly directed and are therefore separated from each other as major points. Points which were duplicated by respondents have been included only once but are noted as having more than one supporter.

(1) One must try to be non-judgemental when discussing borrowing. Are we not grateful for the help in early development of our resources?

(2) One must provide a case for Canadian context not out of its opposition to . . . Americanism or Internationalism, but simply because it makes good sense. The "Canadianization" of science education ought not to be an emotional, or political matter, but simply one of good sense. (More than one.)

(3) In many cases it was felt that many factors do not in fact reflect national contexts.

(4) There was a request for a list of ways in which science, and science education could be "Canadian". The opinion conveyed was that if one could make such a list and argue dispassionately in favour of including these factors in science education, then and only then, could a Canadian context for science education be accepted. (More than one.)

(5) It should be noted that many Americans have worked on Canadian science.

(6) There were too many strands of argument which needed to be more clearly restated.

(7) It must be noted that even pure physics is culturally determined.

(8) What was needed was a more philosophical and less political style of argument. (More than one.)

(9) Don't try to be all things to all people. (More than one.)

(10) Focus on what is the really essential part of the "Canadian Context" that would help to make science education more meaningful. Don't listen to every crackpot that writes on the topic.

(11) The problem ought not to be a political one but an educational one.

(12) There was a need to show that apparent deficiencies could not be attacked without using the club of Canadianization. (More than one.)

(13) In the 1979-81 Alberta Journal of Educational Research there were no science research papers printed.

(14) In elementary science, the content that would be of importance to children's everyday lives would be "Alberta" content (i.e., birds, mammals, energy) rather than Canadian.

(15) There are several "good" sources of Canadian materials for elementary programs. The key is their availability and teachers' knowledge of their existence.

(16) Canada is a leader in energy resources and possibly this accounts for S.E.E.D.S. being listed in the American market, i.e., We

need to use our Canadian context identity to let other countries hear from us. (More than one.)

(17) It was suggested that we should be teaching environmental education rather than science.

(18) In the theoretical perspective, there is a need to distinguish between basic and applied science.

(19) If current teachers in other subject areas are characterized as scientifically illiterate, it will be a formidable problem to get their cooperation in a venture such as encouraging interdisciplinary studies.

(20) There was a contention that some "Canadian science" portrayed was actually technological application of basic science done elsewhere.

(21) A comprehensive philosophy of the type of life and environment desired for the future is probably not possible, therefore, neither is a special philosophy underlying Canadian science. This raises the question: Is nationalism a viable concept?

(22) The corporate elite of Canada, who control corporate wealth and corporate direction (a) do not send their children to public schools; (b) do send their children to private schools; (c) do not utilize universities for professional education. Thus those who control Canada's wealth are not concerned about a scientifically-literate populace.

(23) International travel answers many of the questions we have about who and what we are and how we differ from others.

(24) The Kanata Kit used in Alberta for Grade 8 has a series on famous Canadians--some are scientists.

(25) On first reading this appears to be a very comprehensive basis for the clue structure. I find little in it to disagree with because I am strongly in favor of increased emphasis on a Canadian context in Canadian science education.

(26) There was general concern that the length of this paper will work against its being carefully read by very many people. Therefore, there is a need to shorten it or provide summaries at the end of each major section. It would help readers keep the major ideas in focus. (More than one.)

(27) There is a need to relate relevance to Canadian identity.

(28) There is a need to define what is meant by a national or cultural dimension of science.

(29) Individual teachers decide how science is taught but not what is taught.

(30) With reference to the following: "If students are made aware of this, there will be increased pressure for scientists to communicate with the public. This increased communication would dispel many of the present misconceptions of the role of science in Canada. It would also increase the probability of Canadians being able to wisely monitor the direction science is taking, which requires a sophisticated appreciation of the moral dimension of scientific activity and the role Canadian society can play in the regulation and direction of science." Is this true of a country that has a national identity? If not why will it be true in Canada.

(31) A number of questions arose from the theoretical perspective that respondents felt should be answered.

- If science is non-nationalistic do we need a definition of Canadian context? What do sociologists of science say about national vs. international scientific communities?

- What about regional variations, North, South, West, etc.? Is this a uniquely Canadian problem?

- Is a "human community" such as Canada, of such large magnitude, even possible considering the recent anthropological and sociobiological data on human group size?

- What constitutes the organizational framework of scientists in Canada?

- Are positions such as those by Hardin a true reflection of the people or has it been used as a political ploy by politicians and the media?

- Do Canadians care what science instructional materials reflect and what is the mandate to make them care?

- Is there a Canadian published magazine comparable to Scientific American or Popular Science where Canadian inventions and achievements can be publicized?

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APPENDIX III

A Theoretical Perspective for 'A Canadian Context for Science Education'

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1.0 Introduction

In recent years, much attention has been devoted to science education in Canada. The discussion generated has in part dealt with concern over inadequate emphasis of Canadian context in science education. More specifically, the concern has arisen from the inability of students to relate science knowledge to their own history, culture, and social and physical environment.

1.1 Defining the Problem

Evidence for this inability of students to relate their science knowledge to their Canadian context comes from several quarters. Dubas and Martel (1973, 1975) conducted a survey for the Ministry of State, Science and Technology on science, the mass media and the public. Two thousand people randomly selected across Canada, over the age of fifteen, were surveyed with discouraging results. Two out of three people interviewed (64.4%) could not name a Canadian scientist. Fewer than one in fifteen (6.5%) had some knowledge of two or more Canadian scientists. The same lack of knowledge was evident about Canadian achievements in science: two Canadians in three (61.0%) failed to name any. Three of five (59.6%) could not state Canadian achievements in the sciences.

The lack of a coherent Canadian context pervades all of education in Canada--not only science education. This prompted the Organization for Economic Co-operation and Development (O.E.C.D.) to state that in Canada, there is no clearly formulated concept of education policy set in the context of a comprehensive framework of general social policy (1976). Reforms in education are almost pragmatic and rely heavily on American and British models. The O.E.C.D. conclusions with regard to matters of educational policy were that Canadians not only tolerate modes of operation that non-Canadians would feel were intolerable but accept them happily because they feel that most things have gone along quite well.

In June of 1972, the Commission on Canadian Studies was established by the Association of Universities and Colleges of Canada. Professor Symons, as chairman, was asked to consider the state of teaching and research about Canada in Canadian universities. The Commission included the question of whether or not teaching and research in the sciences were related appropriately to Canadian circumstances. Representations were received from more than fifty scientific associations, and some five hundred scientists personally presented their views (Symons, 1975).

On the basis of its findings the Commission on Canadian Studies made recommendations which reflected the need for a Canadian context in science teaching. They noted that the responsibility for teaching about Canadian science is shared by all levels of education. These recommendations held that improving the amount and quality of Canadian context in our science curricula would have a significantly favorable impact on present and future students.

Following the publication of the first two volumes of the Report of the Commission on Canadian Studies in 1975, a science education colloquium was convened by the Science Council of Canada in October, 1978, entitled "A Conversation about Canadian Content in Science Education". Subsequently, in a paper "A Canadian Context for Science Education", Page (1979) explored the issues and concerns for science educators that were raised at this colloquium. He identified the major areas of concern as:

(i) lack of attention to Canadian dimensions and problems in science teaching and research;

(ii) failure of Canadians to recognize that science and technology are integral parts of our society's culture.

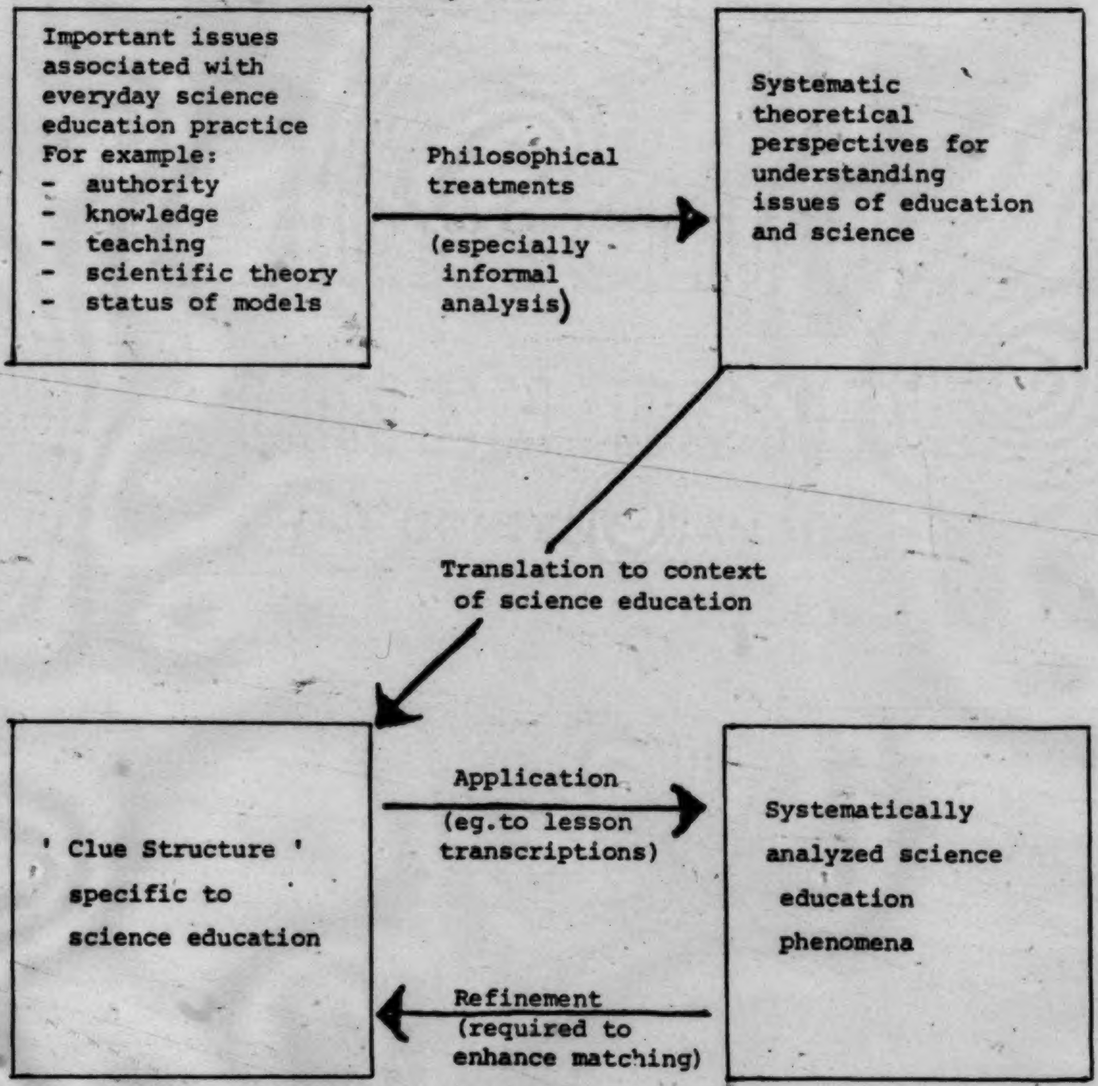
It is obvious that some of the blame for the state of affairs described above must be placed on the science teaching that students have been receiving in our schools. It is not the purpose of this perspective to present an exhaustive critical analysis of this science teaching. However, the central role of instructional materials and their possible inadequate treatment of Canadian science must be dealt with. What has been the general situation in regard to these materials? Basically, in all too many cases, changes in science curriculum and instruction in Canada have been based upon research and development conducted in the United States, and to a lesser extent in Britain. American curriculum projects in elementary and secondary science, including the textbooks and programmes which were produced in connection with them, have been adopted extensively in Canada. Such modifications as have been made have been limited to relatively minor accommodations of local phenomena as noted by Crean (1976). Consequently, the lack of Canadian context in science teaching has resulted primarily from "omission". However, as will be discussed later, the lack of national identity and consciousness in our science instructional materials results in an increasing communication of implicit messages which are not conducive to achieving some of the major goals and objectives of science education in Canada. By identifying a Canadian context for science education and by identifying Canadian ideas that we should be communicating to our students through our science instructional materials, science instruction can become a vehicle for Canadians to add another dimension to their national identity.

When defining a Canadian context for science education we must be able to distinguish between those conceptual interpretations and messages which are warranted for use in our Canadian schools and those which are not since the approach used to convey a science concept affects a person's understanding and appreciation of the phenomenon being studied. If "the scientific information reaching children is fragmented and sometimes distorted in a way that hinders them from interpreting and evaluating the information they receive" as Suzuki (in Dornan, 1977) suggests then we need to teach more than facts, formulas and structures which are of little importance to our pupils' everyday lives. These abstract concepts and facts must be presented in a manner which allows the student to view them as relevant in their cultural and physical environment.

It is now possible to state the problem being addressed by this theoretical perspective: it is to define a Canadian context for science education in Canada. Such a definition can in turn be used (among many things) as a basis of analysis of instructional materials being used by Canadian science teachers.

1.2 A Frame of Reference

The notion of "theoretical perspective" adopted here was proposed as a research paradigm by Roberts and Russell (1975). It is presented schematically as follows (p. 116):


Important issues associated with everyday science education practice
For example:
- authority
- knowledge
- teaching
- scientific theory
- status of models
Philosophical treatments
(especially informal analysis)
Systematic theoretical perspectives for understanding issues of education and science
Translation to context of science education
' Clue Structure ' specific to science education
Application
(eg.to lesson transcriptions)
Systematically analyzed science education phenomena
Refinement
(required to enhance matching)

It should be noted that the ultimate objective in using a theoretical perspective is to analyze systematically science education phenomena through the application of a "clue structure". The development of a theoretical perspective for Canadian context makes possible the evaluation of science instructional materials used in Canadian schools.

To this author some of the important issues or elements associated with the notion of Canadian context in science education and which must be taken into account in the theoretical perspective are as follows: acquisition of basic scientific knowledge and process skills; development of an understanding and appreciation of the nature of the Canadian scientific enterprise (including its modes of inquiry, philosophical basis, and history); development of positive attitudes towards science and its applications with appropriate local, national, and international emphasis; development of an understanding of the meaning, responsibilities, and benefits that science engenders at the local, national and international levels; development of a commitment to the careful use of natural resources in Canada and to the preservation and improvement of the physical environment; and fostering an ability to understand and respond to change as it occurs in personal life and in society through science-society interaction.

The notion of "philosophical treatments" included in the above model poses some difficulties. Different definitions of Canadian context for science education will result from variations in perceptions of the need for defining it and the elements to be included. Therefore, it seems fruitless to strive to reach a consensual definition. Instead, an attempt will be made, with the assistance of others to formulate an idiosyncratic definition. There is no intention to debate whether there is a need for defining Canadian context(s) for science education or whether it is possible -- it is assumed that such a definition is both desirable and necessary. It is recognized that the definition arrived at will yield a specific clue structure, and the subsequent analysis of instructional materials based on this clue structure will perhaps yield "biased" conclusions about them.

The philosophical position taken in defining Canadian context is that of Canadian identity. The intent is not to be purposely nationalistic. Rather, it is arguable that the notion of Canadian context is meaningless without invoking concern with Canadian identity; that is, Canadian context for science education becomes philosophically acceptable within the context of Canadian identity.

Finally, this theoretical perspective deals in detail with each of the significant elements in the definition of Canadian context. Thus, a clue structure[1] emerges logically from these elaborated elements. The actual application of the clue structure to instructional materials and its interactive refinement as suggested in the Roberts and Russell model will not be dealt with in this paper.

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[1] The clue structure is a set of analytical questions or statements which, when answered, will provide specific information about educational phenomena under consideration (e.g., the kind, extent and quality of Canadian context reflected in science instructional materials).

2.0 The Search for a Canadian Identity

Attempting to define a unique Canadian perspective for science education is a difficult task, mainly because there is little organized literature on the subject. The task then becomes one of selecting relevant ideas from all available science education literature (mainly that on teaching science in the social context) and integrating them with selected ideas from the existing literature on Canadian identity.

"One disadvantage of living in Canada" Northrop Frye has suggested, "is that one is continually called upon to make statements about the Canadian identity, and Canadian identity is an eminently exhaustible subject" (Frye, 1977:15). Although Frye suggests it is exhaustible, it is of paramount importance, to anyone contemplating alternative options to present outcomes of science instruction, to pursue the search for a Canadian identity and its relevance to Canadian science education.

2.1 The Perceived Canadian Identity Crisis

It seems that Canadians' pride in their ethnic pluralism combined with historical colonial attitudes has resulted in a diminished concern about Canadian identity. This has given rise to the so-called "identity crises". The seriousness of this issue is even noted outside Canada. "Your nationality", a New York Times correspondent is reported to have said, "consists of an identity crisis with which you have a national love affair" (Hardin, 1974). Many Canadians are certainly preoccupied by the question of who and what we are, how we differ from others, and how we fit into the larger world. Lacking a widely-felt and recognized set of attributes comprising and circumscribing our Canadianism, we "grope" towards a suitable definition of our identity goals and the best means for their attainment.

Contributions to literature on Canadian identity have come from Frye (1977), Hardin (1974), Hodgetts (1968), Snow (1959), Trainor (1974), Crean (1976), and many others. Their collective views can be summarized as follows:

(1) Canadians lack a clear-cut overriding identity which sharply defines their national character and which could alleviate the emphasis placed on variations in self-perceptions related to ethnic, regional, professional or class backgrounds.

(2) The national self-awareness that does exist is low key and often unconscious. However, the idea of anyone being 100 percent Canadian or un-Canadian is absurd. A person's sense of identity will be closely related to knowledge of the lives and concerns with whom one primarily identifies. Therefore, a majority of individuals may well have a feeling of commonality with foreign nationalities which is stronger than that towards a Canadian one. In a way this may be a positive feature since it ensures a sense of internationalism combined with one of nationalism.

(3) There are many perceptions of Canadian identity in Canada. These are not always compatible or congruent. One feature of national identity is the manner in which the citizens of this country perceive the political expression of their nationality; that is, perceptions of the local, provincial and federal levels of government. Varying per-

ceptions of provincial and federal political jurisdictions lead to problems of regionalism and alienation which subsequently affect our feelings and conception of national identity. The effect of geographical distribution of people in Canada must also be noted. The feeling of Canadians in the western regions who feel closer to the United States than to eastern Canada and Quebec critically impinges on Canadians' sense of identity.

(4) Individualism, though tempered by something like the public enterprise ethic, is strong and pervasive. Shared group interests, particularly on the national scale, are played down as a rule, in favour of opportunities for individual or particularistic ends to be pursued, often at the expense of the collectivity. This is closely tied to and is in fact part of the highly developed commercialism of Canadian values. Canada's toleration for foreign control and influence over its economy and culture, so strikingly visible in the physiognomy of Canadian cities and towns, in its school curricula, and in practically everything we do, is unique. Analysts both inside and outside Canada observe that no country has been so willing to be exploited, or to have so supinely encouraged the take-over of its resources or mind as has Canada. This national abdication is a natural outgrowth of a value system dominated by acquisitive and materialistic considerations. These same analysts provide ample testimony to the existence of people in our country ever ready to peddle the dreams of their forefathers for a price. The strong commercial streak in the value system (intimately related to an unrestrained individualism) has affected more than our

response to foreign, and particularly American expansionism. It has also, and in some ways more importantly, influenced other decisions. It has often been easier to borrow or buy other people's ideas, technologies, aesthetic works than to develop and encourage our own, but one wonders at what price to future Canadian development.

(5) Members of the mass public and elites, even those who have a reasonably well-informed and basically sympathetic response to Canada's problems, tend to lack realism about the character and severity of the country's economic, cultural and political difficulties.

The views on Canadian identity listed above certainly smack of an identity crisis and illuminates to some extent why science education in Canada has not been rooted adequately in a Canadian context. Are these views widely held in the different spheres of Canadian life? It is beyond the scope of this theoretical perspective to deal broadly with this issue. However, it is of concern to analyze the identity question in Canadian science.

2.2 Nationalism and Internationalism in Canadian Science

To an important extent a Canadian context in science education must be rooted in a Canadian dimension of our science and technology. Is there a national as well as an international dimension to science? If there is, what are the respective national and international components and their inter-relationship?

According to Symons (1975), Page (1979), Hayes (1973) and others there are differing views of this issue of nationalism and internationalism in science. Some scientists vigorously reject the notion that science has any place in Canadian studies. There is widespread belief that science is universal in nature and should not be restricted by national boundaries and considerations. Some scientists suggest that because of the universal basis of science, it is inappropriate to speak of 'Canadian science'; they deplore suggestions that their activities have a national flavour. The scientific worker, with an objective outlook in his own field and able to meet those in other countries on common ground is inclined to pride himself that he has established an international framework which can serve as a model for all other fields of endeavour. At the same time, there also appears to be an assumption that when Canadian academic interests, priorities and values differ from those elsewhere, they are necessarily inferior.

The Symons Commission Report (Symons, 1975) states that it is misleading to suggest science is only international; that it does not have a national or cultural dimension. Science is not just a set of laws. Trainor (1974:32) defines science as "an activity which involves people, attitudes, aims and processes. It is as much a part of the cultural fabric of a nation as it is a pillar of technology. Scientific laws may be universal: scientific practice is not". Polanyi supports this view that science is very much a part of the culture of a country: "It has more that is new to tell us about who and why and what we are than any contemporary branch of human knowledge". (1972:28)

The literature on the national versus international character of science is an abundant one. An exhaustive survey is not essential for this study, but its main arguments can be summarized as follows:

(1) There is science which in a broad non-nationalistic sense includes discovery of scientific laws and development of scientific theories. There are also underlying methodologies of scientific inquiry which are universal. These basic abstract concepts of science and the associated modes of inquiry constitute an important part of the foundation of science education.

(2) There is science done in Canada which some identify as Canadian because it was done by Canadians. This is not a sufficient reason for such labelling. However, scientific knowledge is based on observation of things and events, and many Canadian scientists are indeed engaged in observing the Canadian environment. Even some of the investigative skills and associated technology employed in the scientific study of the Canadian scene obtain a national character. The O.E.C.D. examiners recognized Canadian uniqueness when they stated that "it would be hard to find any country whose scientific structures and attitudes towards science are more clearly rooted in geography and history" (Hayes, 1973). This position was supported by the Symons Commission, which suggested that the special nature and circumstances of Canada require special attention and that Canadians have a responsibility to the international community to deal with specific questions and problems posed by our land. An appropriate example is the field of Canadian geology. Undoubtedly, an understanding of the diverse geology of our vast land is important not only for our national well-being but also to an understanding of the geology of the entire earth. For this reason many non-Canadians have also been involved in the study of Canadian geology. In this specific

area of science the national and international components both separate and blend.

(3) Science acquires a Canadian character because it is very close to the center of the Canadian experience, with intimate connections to long and closely held Canadian political, economic and social ambitions; that is, science has a significant impact on economic, technological, political and social aspects of Canada. As Peterson (1980) and others point out, science cannot flourish without scientists who in turn require a national organizational framework that will sustain and coordinate their activities, and an economic role to justify national financial support for their livelihood and work.

One is attracted to the view of Brouwer (1980) that since science has shown itself to be potentially at least an area in which men of all nations can work together, the Canadianization of scientific research and education must not be carried out for 'nationalistic' reasons but simply because science and technology can best show their value to all people if they are applied first of all in the local setting in which the research and teaching is carried out. Despite differences of opinion, the question of Canadian identity does not seem to reach the same critical proportions in science that appears evident in other spheres of Canadian life. The one sphere in which the question of Canadian identity is critical and of concern to this perspective is Canadian science education.

2.3 Identity Crisis in Canadian Science Education

If there indeed is an identity crisis in Canadian science education, it is perhaps most evident in the some of the outcomes of science teaching. As was alluded to earlier, the Symons Commission report provides a well-founded catalogue of neglect of Canada in scientific research and teaching. In the 'Science and Technology' chapter it is concluded that Canadian school children learn virtually nothing about "the accomplishments and impact of science in their own country, and the reason is they are not being taught such matters" (Symons, 1975:162). Symons' Commission added that in the area of science education, there was an almost unparalleled story of neglect and missed opportunities. They reported that science students "showed a general lack of awareness - often bordering on ignorance . . . of contemporary and historical Canadian society" (Symons, 1975:151).

The consequences of the pervading neglect of Canadian science according to the Commission, is that "scientists and laymen alike fail to consider science in a uniquely Canadian context and, on the whole, are unappreciative of the cultural role played by science. They never thought about science in an integrative way and have never been exposed to these considerations at any level of their formal schooling" (Page, 1979:18).

Hodgetts claims that this neglect of Canadian context in education is partly motivated by an attitude, exhibited by some Canadians, that they "could not care less" about Canada, being internationalist to the core. The attitude that our country has nothing unique to offer and why "bother with Canada when considering science when the problems of the world are so pressing?" can have a very detrimental effect on science education in Canada. Hodgetts (1968:92) also suggests "that the present emphasis on the changing nature of society, on the resulting doctrine that all knowledge is relative and that it does not matter what we teach, is one of the most damaging ideas in Canadian education today".

The criticism that current science teaching does not adequately treat the science-society interaction has been around for a long time and is of international scope. In Britain, Snow (1959) was among the first to suggest the need for teaching science in a human and social context rather rigidly emphasizing the conceptual structure of scientific disciplines. More recently in the U.S.A., Yager (1980) presented science education as being the discipline concerned with the interface between science and society. Yet the three major studies of the status of science education in the schools in the United States (Helgeson, Blosser and Howe, 1978; Stake and Easely, 1978, and Weiss, 1978) as well as his own, indicated disparity between the goals of science education reflected in current science teaching practice and the needs of society.

As has already been indicated the science-society interaction is also virtually absent in science teaching in Canadian schools. In addition to Symons and Page other prominent Canadians (for example, Bachynski, 1973; Aikenhead, 1980; Suzuki, 1980) have added their voice to the notion that the social context of what the student has been taught in the classroom is the most important contribution of science teaching. Because this social context is largely absent, the majority of Canadian society is alienated from science and does not feel science has much relevance in daily life, despite the fact that it does have a profound effect.

Symons (1975) and Page (1979) point out that two significant contributing factors to the lack of a Canadian identity in science education are:

1. Science seems rigidly disciplinary in orientation, consequently denying science students opportunities to learn about their country's history, politics, sociology, etc.

2. A lack of Canadian textbooks and excessive reliance on non-Canadian teaching materials in a broad range of areas. Page (1979) describes a review of the curriculum guidelines for Ontario elementary and secondary school science courses as a striking case which could be considered representative of other areas in Canada. "Very few Canadian texts are suggested as readings for students and the guidelines do not reflect a Canadian context except in the most perfunctory way. Further, in discussions with curriculum co-ordinators in the Ministry, it was made clear that, in their view, few recommendations on Canadian context were followed and they were, in large measure, 'lip-service'. The reasons given were: the lack of Canadian support materials; teachers have little or no training in 'Canadianizing' their science curriculum; and science teachers, feeling pressured to prepare their students for undergraduate work at the university level consider themselves under such time constraints that they could not bother with the 'peripheral' matter of relating science to the Canadian context. The important point is the lack of texts was cited as the major problem" (Page, 1979:38).

3.0 A Canadian Context for Science Education

3.1 A Case for Canadian Context in Science Education

Page (1979) suggests that the most significant result of the Science Council's colloquium was a firm statement that adequate recognition of a Canadian context for science education be a basic educational objective. If Canadians understand the relationship between science and society and if they are able to comprehend Canadian science issues, they will be able to deal more effectively with Canada's future. A decade earlier Hodgetts (1968) claimed that within the almost limitless diversity of our open, pluralistic society, Canada is unique because of the particular set of problems its people face at any given time and that these problems have grown out of the history of Canada. By ensuring a Canadian context our schools would enable elementary and secondary education in Canada to play a much more inspiring role than they had in previous decades.

The conclusion to be drawn from the evidence and argument presented in this perspective to this point is that there is a need to re-examine the goals in science education established by various educational systems in Canada, so that the identity crisis of science education be resolved and that it be resolved by taking the Canadian context into account. This is a responsibility that all Canadian science educators must assume. If they do not then the disparity between the outcomes of current science teaching in Canadian schools and the needs of Canadians and Canadian society will continue to grow and become increasingly more difficult to resolve.

A Canadian context for science education can assist in reducing this disparity by basically doing three things. First, in order for Canadians to use science creatively to solve problems in Canada, they must obtain a holistic view of the nature of science and its relation to Canadian society. By increasing the awareness of the nature of the scientific enterprise in Canada, a Canadian context will allow Canadians to make a realistic assessment of the potentials and limitations of science for resolving serious problems in Canada, which in turn may lead to increased support for scientific ventures in Canada. Secondly, a

Canadian context in science education can assist students to cope with societal problems and pressures in part created by science. It can do this by providing the student with the opportunity to acquire basic knowledge, skills and attitudes in science with appropriate local, national, and international emphasis. This would include having students to do their own investigations relevant to their social, physical and biological environment to achieve a realistic frame of reference on the purposes and potential of science. Thirdly, a Canadian context for science education could help to ensure that the intents of producers of instructional materials for science would be congruent with the rationale, goals and objectives of science programmes in Canada which already profess concern with Canadian content.

3.2 Definition of a Canadian Context for Science Education

For the purposes of this theoretical perspective, Canadian context, in its all-encompassing definition, includes all prevailing knowledge, beliefs, values, morals, customs, laws and other attributes which are specifically associated with individuals who inhabit the boundaries of Canada. It also includes influences on these cultural components such as history, tradition, population mix, geography, science and technology, and the political and economic system. Because of the uniqueness of the preferences, beliefs, behavior and circumstances of Canadians, it is deemed possible to speak of a Canadian identity.

Obviously, a Canadian context for science education must be narrowed down to the cultural components and influences which are of immediate concern (and indeed responsibility) of science teaching. In the main these are inherent in the unique historical and current characteristics and contributions of Canadian science, the philosophy underlying science activity in Canada and the relationship of Canada's history, economics, politics and sociology to science.

A number of specific content and methodological components for science teaching have been identified in this perspective to account for the multidimensionality of Canadian context described above. Those content components which should be incorporated into programs to ensure a Canadian context for science education include the interdisciplinary nature of science, Canadian science-Canadian society interaction, history of Canadian science, philosophy underlying Canadian science, the interrelationship of pure science and Canadian applied science, science as inquiry, and the interaction of Canadian science policy and current research emphasis in Canada. Methodological components which are included in the pedagogical strategy of presenting a Canadian context are use of local Canadian environment, Canadian written textbooks and other instructional materials, methods of adaptation of foreign instructional materials to a Canadian context as well as handling problems of regionalism in Canada. Each of these components will be dealt with in detail below.

4.0 Elements of Canadian Context in Science Curriculum and Instruction

A Canadian context for science education indicates a need for open discussion of the goals and purposes of science education in Canada. Once these are agreed upon, the present science curriculums in Canada must be looked at and the underlying rationale defined. Finally, the congruence between goals and instructional materials must be determined. As Yager (1980) suggests, any reconceptualization of science education must establish the validity of its rationale in terms of synthesis and a normative/theoretical analysis of research influencing science teaching including studies of intellectual and social development, educational policy and goals, curriculum organization and instruction practices.

Science instruction in a Canadian context must be considered in an integrative way in relation to Canada's history, politics and sociology. We must now consider how its content and activities can be made to contribute toward the goals of more effective citizenship of Canadians.

4.1 Content Components of Science Education in a Canadian Context

4.1.1 Interdisciplinary Nature of Education

Many problems in science education have been created by a self-imposed dichotomy where the sciences and humanities are split into completely separate categories of disciplines. Yet we profess that all living things interact with and are interdependent upon each other and their environment. Therefore, students will truly understand phenomena only if they study them in their integrated complexity. Schwab (1964) noted that this requires studying functional relationships in phenomena which go beyond the individual characteristics of the parts. For this type of study, students require an interdisciplinary approach, involving in the first instance science and social studies. An advantage to an interdisciplinary approach is that it can accomplish what single disciplines cannot.

If Canadian students are to understand and keep abreast of change in Canada, they must study the interrelationships of science to other facets of Canadian life in an interdisciplinary manner. Stamp (1980) emphasizes that any one curriculum subject or academic discipline is not a sufficient vehicle for promoting national awareness and national identity. He suggests that the whole can become greater than the sum of its parts through interdisciplinary studies. Science, combined with aspects of social studies and Canadian studies could assist them in developing their perspectives of national identity and the role science plays in defining that identity. Focussing specifically on the science contribution to interdisciplinary study in Canadian context, Nay (1976) advances the following objectives:

(i) promote an understanding and appreciation of the effect science and technology on modern Canadian society,

(ii) through study of science in its social context, examine the historical interaction of intellectual and social activities,

(iii) bring about an understanding and appreciation of man's inter-relatedness with his natural and social environment,

(iv) assist in developing intellectual tools the student may use to be productive in our rapidly changing environment such as critical-mindedness, decision-making skills and many others,

(v) promote Canadian science education as a relevant and functional experience, and

(vi) allow Canadian science students the opportunity to experience a holistic view of man.

Admittedly, the history of interdisciplinary education has been a dismal one both in Canada and other parts of the world. Strong efforts must be made to develop curriculum frameworks which would allow the integration within a Canadian context of what are now separate subjects in schools.

4.1.2 Canadian Science-Canadian Society Interaction

Science-society interaction can be studied in schools in a meaningful way only through a broad interdisciplinary approach. However, it is possible (and currently more expedient) to study this interaction more narrowly in a science education context. The importance of this goal in science teaching has already been alluded to. What are some of the specific elements which must be addressed in the science-society problem? The following are probably the major ones taken in reference to the Canadian context:

(i) An understanding and appreciation of the relationship between science and Canadian society. Specific attention must be given to the impact that science and technology have on Canadian society and culture. Such instruction should provide ample examples and illustrations of this impact from contemporary Canadian life.

(ii) Science education as part of our total Canadian culture. As Aikenhead (1980b) points out, science should be presented as a way of getting to know ourselves and our universe.

(iii) Depicting how science and technology can be used to alter the economic and political situation in Canada. This is necessary since the quality of life in Canada will be determined by the way people respond to application of science and technology (Symons, 1975). In a science classroom attention must be given to the scientific, technological and social problems facing Canada and indeed the world, and ways of resolving these issues. The latter will require that attention be given to processes of decision-making for resolving science-related social problems. Consideration should also be given to Aikenhead's suggestion that a "consumer-oriented" science and society approach be used in science teaching for students to deal with science-society issues.

(iv) The variety of roles that high school students as adults will play in Canadian society in the future and how science can prepare them for those roles.

4.1.3 History of Canadian Science

It has been noted by Jarrell (1977) and others that even highly educated Canadians are almost totally ignorant of many important Canadian achievements in science, as well as the impact that science and technology have had historically upon Canadian life. Nor do Canadians appreciate the part played by scientific breakthroughs, both at home and abroad, in shaping and making possible the development of this country.

The implications of the above indictment are obvious. The history of Canadian science must be included in science curricula to develop in students an awareness and appreciation of this scientific history as well as the significant role of Canadian scientists and technologists in Canada's growth and development. For example, Levere (1980) notes that early Canadian achievements in science, which included the mapping of resources, identifying and classifying species, and exploring the natural history of the land as a prelude to settlement, were impressive since most successes came largely from individual enterprise. It is also essential to include the significant contributions made by Canadian scientists to international science.

If a student is presented science in a Canadian context which includes significant historical achievements, a sense of Canadian identity and pride is conveyed.

4.1.4 Philosophy Underlying Canadian Science

It is difficult to discern whether there is a specific philosophy that guides the work of Canadian scientists (if there is, it is perhaps an eclectic one). However, there are historical and social influences which helped to determine how science was launched, developed and utilized in Canada.

Levere (1980) suggests that the most important scientific legacy from Britain was the ideology and educational practice of the Scots who believed that science was not only a tool for the understanding of nature, but also as a tool for the enrichment of mankind through development and exploitation of nature. Levere also identifies confrontation with the land and entrepreneurial ideology as the two factors which contributed most to give science its special place in Canadian society and culture. The science that emerged was in turn significant in shaping Canadian society and culture.

Peterson (1980) also identifies the adoption and adaptation of laboratory technology and science to the solution of Canadian problems as an important event in the history of Canadian science. He supports the idea that "the necessary condition for the generation of a first approximation to Canadian science--a Canadian adaptation of European science--was its integration with production and its grounding in the material realities of Canadian life" (Peterson, 1980:133). Canada was unique in that the advance of science followed technology which defined social needs rather than preceded it: "An economic base was created by linking science to industry and plowing some of the surplus produced by the scientifically rationalized industrial machine back into science itself. Science, in turn, had to increase the breadth of its technological base in order to overlap its work with the existing industrial technology. This lead to the rapid development of laboratory science" (Peterson, 1980:131). Peterson (1980) also notes that scientific societies and associations of scientific professionals provided the early organizational framework for Canadian science.

If students of science education in Canada are to understand the course science has taken in Canada and our present emphasis on natural resources, they must be made aware of the tradition in which science is done in Canada.

4.1.5 Pure Science, Canadian Applied Science and Their Interrelationship

Students must be able to understand the nature of both pure science and of applied science (technology) which Paul DeHart Hurd

(1975) states serves as a bridge between science and society and acts as a unifying force between the various disciplines. According to Berkheimer and McLeod the relationship of pure and applied science can be stated as follows: "Science attempts to describe the world as it is while technology remakes the world to serve human desires and needs . . . it is the means by which humans adapt the environment to suit their needs" (1979:39).

Of great importance to a Canadian context for science education is that by stressing the interrelationship of pure and applied science, emphasis is also placed on the concern "that science be taught in such a way that issues of pressing national concern relating to science and technology receive a central place in the classroom experience of students" (Orpwood and Roberts, 1980:3).

All too often in science courses the concept of applied science and its interrelationship with pure science is omitted. This omission can lead to alienation of students from theoretical science. For example, Weisskopf (1976) and others feel that physics is considered inhuman by many people because of its abstract and mathematical concepts which in many cases deal with matters under conditions far removed from the human environment and direct human experience. If physics is taught as an interactive with applied physics, this alienation might not occur. Too often, pure versus applied science has resulted in conflict of views and subsequent confusion for students.

With respect to the curriculum Hurd (1975) suggests applied science puts science concepts in everyday affairs where the student confronts them. The student must be aware how "applied science" can be used to interpret critically what is taking place around him. However, Berkheimer and McLeod (1979) warn that to ask students to resolve complex problems in applied science before they have a substantive scientific background is to create feelings of futility and frustration.

4.1.6 Science as Inquiry

Science as inquiry is a major element in scientific literacy. The theory and practice of teaching science as inquiry has been well developed (Schwab, 1962, 1969; Brandwein, 1962; Romey, 1968; Gagne, 1963; Nay, 1971; and many others). According to Schwab (1962), science as inquiry has two sub-elements: the learning of science _as_ inquiry (often designated as _content_), and learning science _by_ inquiry (often designated as _process_). It is desirable that both of these sub-elements be strongly reflected in science teaching in Canada, and that appropriate Canadian context be incorporated as follows:

(i) When dealing with specific achievements of Canadian scientists that some attention be paid to the methods of inquiry used (for example, in the form of case studies) and to the social, economic and political circumstances making the achievements possible. It will be also beneficial to relate the Canadian discoveries to the total discipline as being developed internationally.

(ii) Students be given opportunities to apply inquiry strategies when dealing with pressing Canadian problems which require a scientific/technological solution (e.g., in environmental degradation, resource depletion).

4.1.7 Canadian Science Policy, Current Research Emphasis in Canada and Their Interaction

Scientific research and applied science are important to Canada and Canadians. As has been mentioned already, students must become aware of the effects science and technology has on them and on Canada's position in the world community. In addition they must come to understand and appreciate why there is emphasis on certain areas of research in pure and applied science. Inclusion of a simplified treatment of Canadian science policy in the science curriculum seems desirable. Robertson (1978) reveals that the average person on the street is not interested in anything but the practical results of science. This attitude is a direct result of people being educated in science without a knowledge of what is taking place in science research and applied science and why.

The following sub-elements seem to be of concern in science education relative to science policy and research emphasis:

(i) The science policy debate which has existed in Canada since the early 1960's with the original objective being to devise mechanisms by which we could more effectively "use science in the service of the nation and include mobilization of scientific effort to solve perceived national problems" (Forsyth, 1977). Students can be informed of the milestones in this science policy debate (as outlined by Bachynski, 1973), and the dynamics of science policy formulation. For instance, the findings of the 1960 Glassco Royal Commission that the science policy of Canada was "the result rather than the cause of growth in many scientific activities undertaken by the government and formation of the Science Council of Canada in 1966."

(ii) Determinants of Canadian science policy: concern with the survival and maintenance of the nation, strengthening of indigenous technology in order to eventually make our 'branch plants' independent, a concern for our environment, maintaining the status of academic science, etcetera.

(iii) Changes in science policy in Canada over the past decade: "mission" or "task-oriented" research, increased involvement of provinces in pure and applied research, development of special institutes or centers for applied research, tax write-off for research done by industry, etc.

(iv) Areas identified as being of specific interest and benefit to Canada: communication, management of the oceans (especially the Arctic), transportation, oil and gas technology for severe climatic and geography conditions, resource development, etc.

(v) Assessment of the adequacy of Canada's science policy: why research and development support for pure science is so low, why Canada has the lowest science budget as a percent of the GNP of all the OECD countries, why governments are increasingly dictating the kind of pure and applied research being done, etc.

4.2 Methodological Components of Science Education in a Canadian Context

4.2.1 Maximum Use of the Local Environment

If students are to comprehend the relationship of science and technology in their lives, they cannot deal in abstractions alone. They must be able to relate abstract knowledge to concrete situations which they have encountered. It is therefore essential that the science teacher provide experiences and examples which will serve as concrete illustration and reinforcement of the science concept being learned.

Students must develop a deep understanding and appreciation of the natural and social world in which they live. Therefore science concepts should not only be illustrated constantly by concrete local examples, but the student should also be required to apply basic scientific laws and concepts to the study and understanding of his immediate environment.

Finally, students should be required to deal with topics and problems of current local scientific significance and to take feasible action on suggested solutions. This will help to develop in students a commitment to the careful use of natural resources in Canada and to the preservation and improvement of their environment.

4.2.2 Canadian Science Instructional Materials

There is a demand for Canadian produced science instructional materials, yet on the whole, as Page (1979), Symons (1975), Dornan (1979) and others point out, this demand is far from being satisfied. The talent for producing these materials in Canada is not lacking. Many local initiatives have resulted in high quality curriculum materials, and several have attained national and even international recognition: ALCHEM (Jenkins, 1978), Science: A Way of Knowing (Aikenhead, 1977), S.E.E.D.S. (1979), C.R.I.B. Project (Nay and Associates, 1972), Physics, A Human Endeavour (Paul, Pierce and Stief, 1973) and many others. All that needs to be provided for the production of an ample supply of Canadian science instructional materials are appropriate professional and economic incentives and support.

Instructional materials for teaching science in a Canadian context must meet at least the following criteria:

(i) It must contain Canadian content that students can relate to their own life and environment; i.e., it must be highly relevant to students.

(ii) It must include, wherever relevant, information on Canadian science and scientists, the Canadian science-society interrelationship, etc.

(iii) It must be of high quality in terms of content selection, organization and presentation.

(iv) It must contain implicit messages that are congruent with teaching science in a Canadian context.

4.2.3 Adaptation of Foreign Science Instructional Materials to a Canadian Context

Foreign materials (mainly textbooks) will continue to be used extensively in Canada in science teaching for a long time. There are a number of reasons for this. Economies of scale of production are derived by selling instructional materials on an international market. Provincial ministries of education and local school boards are usually reluctant or unable to support curriculum development and distribution. Finally, most scientific knowledge does not have a "national" character, and indeed we would want our students to continue studying about science in other countries.

How can our heavy reliance on foreign instructional materials be brought in line with a rational approach to teaching science in a Canadian context? Currently, for some specific purposes or needs, instructional materials are being produced with an appropriate Canadian bias (e.g., for the study of regional flora, fauna and geology. Hopefully, this practice will increase dramatically, especially in areas which have been virtually ignored to date (e.g., the Canadian science-society interaction). Occasionally, foreign books are revised (preferably by Canadians) to include Canadian emphasis, examples, activities, etc. Again, hopefully this practice will increase. In the case of use of good foreign instructional materials that have not been revised, teachers' guides should be prepared to show how the materials can be used (e.g., by appropriate supplementation) more in line with Canadian educational circumstances and needs.

4.2.4 Problems of Regionalism

The main thrust of science education in a Canadian context is that the students' knowledge and attitudes relate to all of Canada. There should be no room for regional "chauvinism" and indeed teaching science in a total Canadian context should help to combat this problem, to develop in students a national conception of this country's scientific and technological needs.

Science in a Canadian context can overcome attitudes of regionalism by bringing the unique problems of each of the major areas in Canada together into one context--a Canadian context. Students should understand and appreciate the regional differences that exist in Canada and as was mentioned above base much of their science studies on the local environment. Simultaneously they should learn that all of the regions of Canada are interrelated through such concerns as climate, energy production and use, protection of the environment, and development and use of resources.

5.0 Conclusion

To achieve all of the aims and goals of science education stated in documents issued by ministries of education in Canada it is necessary to use a balanced variety of contexts. Arguments have been presented to show that the aims and goals related to a Canadian identity in science education have been badly neglected. Elements or components have been identified and elaborated for redressing this neglect. Only if a Canadian context for science education is included for the teaching of science in Canada can we be assured that at some point in the future there will be a majority of scientifically-literate Canadians who can understand the tremendous effect science and technology has on their lives, and who will be psychologically prepared to make a significant contribution to the development of a Canada which is increasingly reliant on science and technology.

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APPENDIX IV

Appendix IV includes:

(1) A copy of the cover letter to the national sample of validators.

(2) A copy of the letter sent to non-respondents.

(3) Outline of the revised Theoretical Perspective used for cataloguing comments of respondents in the national sample of validators.

(4) Comments provided by the respondents in the national sample of validators.

Fellow Science Educators:

A Theoretical Perspective for 'A Canadian Context for Science Education' is the basis of a clue structure which I am devising as part of my M.Ed. thesis. The clue structure will serve as a foundation for examining instructional materials to determine the type and extent of Canadian context that has been included.

In order for my theoretical perspective to reflect a realistic view of a Canadian context for science education, I am soliciting reactions to it from science educators across Canada. You were suggested to me as a person who might be willing to spend the time and effort necessary for such a reaction. I would appreciate your contentions, support, note of errors or omissions, need for additions, etc. In reacting to this perspective, please use the wider left-hand margin to make comments at appropriate points or write them on the back of the paper.

To enable me to pursue my M.Ed. study with all possible haste please return the theoretical perspective to me with your comments by March 31, 1982. All contributions will be held in confidence, and will be acknowledged in the thesis.

If you have a colleague who would be interested in reacting to this document, feel free to duplicate and pass it on.

Thank you for your valuable input.

Gratefully yours,

Rick Mrazek

Rick Mrazek

April 8, 1982

Dear Colleague,

Towards the end of February you received a copy of a theoretical perspective for 'A Canadian Context for Science Education'. I realize that for most participants the requested deadline of March 31 was simply too pressing.

I will be pursuing this investigation beyond this M.Ed. study phase, therefore I would still appreciate your reactions to my theoretical perspective at your earliest convenience.

Based on those reactions received to date, contributors have a wealth of ideas regarding a Canadian context for science education. These reactions can play a vital role in the direction of my research.

I look forward to hearing from you and sincerely hope you have the the opportunity to react to the document which you received.

Gratefully yours,

Rick Mrazek

Rick Mrazek

RM/cl

Stage IV Reactions to A Theoretical Perspective for 'A Canadian Context for Science Education

Reactions in this Appendix are given for each of the respondents in Stage IV of this study. These are either directed to specific sections of the perspective or given as general comments depending upon the context in which they were received. If no comments were directed to specific sections of the perspective, those headings shall be omitted for that respondent. The headings to be used shall include the following which also correspond to headings used in the perspective:

1.0 Comments Pertaining to Specific Sections of the Perspective
    1.1.1 Defining the Problem
    1.1.2 A Frame of Reference
    1.2.1 The Perceived Canadian Identity Crisis
    1.2.2 Nationalism and Internationalism in Canadian Science
    1.2.3 Identity Crisis in Canadian Science Education
    1.3.1 A Case for Canadian Context in Science Education
    1.3.2 Definition of a Canadian Context for Science Education
    1.4.0 Elements of Canadian Context in Science Curriculum and Instruction
    1.4.1 Content Components of Science Education in a Canadian Context
    1.4.2 Methodological Components of Science Education in a Canadian Context
    1.5.0 Conclusion
2.0 General Comments

Reactions shall also be given in a manner which will reflect the group they represent (as noted in the Design) and their connection to science education. Names of respondents have been omitted. Wherever possible, the reactions have been noted exactly as received to prevent alteration which may change their explicit meaning. In some cases, where comments were made in the text of the theoretical perspective, it has been necessary to relate the comments in the context they were perceived.

A. Canadian Science Educators' Reactions

Science Education Professor (A1)

1.1.1 Defining the Problem

On the first page, you observed the "discouraging results" of the survey conducted by Dubas and Martel. Unfortunately you do not give us (or Dubas and Martel do not make available) enough information to make the conclusion that the results are really discouraging. As you well know, scientists cannot arrive at a logical conclusion without using control groups. Some controls would be following: Can you name any scientist, e.g., Linus Pauling? Can you name any mathematician? Can you name any Canadian mathematician? Can you name any social scientist, e.g., an historian or sociologist? Can you name any Canadian social scientist? I suspect that the two out of three people interviewed who could not name a Canadian scientist, probably could not name any scientists or any mathematicians, or any social scientists, etc. They might know a few politicians and movie actors, but not learned scholars! If my guesses are correct, then we should be discouraged over the general level of ignorance about learned scholars in our Canadian society.

I note that some science educators in Canada are very alarmed about the lack of recognition of the great achievements of Canadian scientists. On the other hand, please listen to the Canadian scientists. They will quickly explain that the miserably low level of public funding for research in the sciences in Canada does not allow Canadian scientists to compete well with researchers in other industrialized nations of the world. Canadian scientists are constantly talking about the need to fund research at 2 or 3 percent of the gross national product as is done in the U.S.A., Japan, West Germany, etc. At less than 1% of the GNP, the federal government of Canada has condemned scientific efforts in this country to mediocrity. The important message for the public is that much greater funding is needed. If science educators spend their time emphasizing the greatness of Canadian scientific achievements, they will be ignoring the urgent plea of Canadian scientists who are telling us: "We can't compete well internationally because pathetically little funds are available for research in Canada!" Should Canadian science educators ignore the obvious pleas of Canadian scientists and pretend that Canadian scientists are making great advances while Canadian scientists are struggling to make modest achievements? What is the logic of this strange difference in understanding and insight between science educators and scientists in Canada? Perhaps science educators are being led by Ottawa's desire to ignore the petitions of scientists for increased (and desperately needed) funds. Perhaps the federal government is encouraging through the Science Council of Canada an emphasis on the great achievements of Canadian scientists precisely to cover up the urgent need to demand adequate funding for better scientific research.

On page two you observe that the O.E.C.D. concludes that "Canadians not only tolerate modes of operation that non-Canadians would feel were intolerable but accept them happily because they feel that most things have gone along quite well." Nevertheless, this statement merely points out the confusion of the authors. Canadians are intelligent in borrowing curriculum materials, etc. from American and British models.

Yes, they are correct in recognizing that most things have gone along quite well precisely because they have been able to use the excellent materials, insights, wisdom, etc. from large nations. Should we praise those who insist upon re-inventing the wheel or call them idiots? I believe that Canadians are brilliant in their "tolerance" of cooperative attitudes. On the other hand, juvenile nationalism that demands only home-grown authors is silly, and certainly counterproductive in science education. Because of the geography of North America, we should anticipate easy acceptance and exchange of goods and ideas across the U.S. and Canadian border. American textbooks, e.g., in the B.S.C.S., etc. have been translated into many languages, including Russian, and are used around the world. What have Canadians achieved by attempting to limit the use and influence of American textbooks developed at a huge cost to the American taxpayers? The NSF has given over 16 million dollars to the B.S.C.S. for writing textbooks. The Canadian government has provided no funds for the development of science textbooks. If we want to make intelligent complaints, should we not be complaining about the total lack of funding from the Federal government of Canada to support science education materials development? Why doesn't Canada have a National Science Foundation with generous funding for appropriate projects? Before walls are built, let's make sure that science education will be improved and not merely reduced to mediocrity by the exclusion of excellent materials from other Anglophone sources.

Among your references is "An Engineer's View of Science Education" by Donald George. I strongly agree with George's analysis: science is international and lacks any national context; technology is the engineer's application of scientific principles, often in a localized way to meet local or national conditions. Obviously appropriate technologies in poor third-world countries should differ greatly from those of the energy-rich, highly industrialized nations. George is correct in observing that we are talking about technology (not science) when we explain the context of "science." Page wants technology introduced within our teaching of science courses. This is good and I strongly agree. Page (as discussed on your page 3) is not adequately complete in explaining and defining differences between science and technology. Although George is good about describing Canadian technologies, I can give you an interesting reference to an apparent failure of Canadian technologists to seek adequately the importation of foreign technologies which should be utilized here. Economic opportunities are being lost by the failure to import more foreign technologies into Canada. Frequently Canadian technologies cannot be exported because they are not energy efficient.

On page 4 there is an explicit appeal to use science instruction as a vehicle for promoting Canadian national identity. I'm glad that you state clearly what the goal is. Certainly such a goal will seek to ignore the international nature of science, will avoid evaluating curriculum materials on the basis of their excellence to provide concepts of science, and will seek to replace rigorous, abstract science with discussions of localized technologies. As a science educator, I find this nationalistic goal quite unfortunate. We know that the creationists want to teach so-called creation science in the biology classrooms to replace evolution. Judge Overton in Arkansas has ruled that creation science is nothing but the Bible disguised as science.

What are we attempting to do in Canada? Are we attempting to replace science with nationalistic history? Have political goals become so important for producing a Canadian identity that we must now get rid of science teaching to provide this disguised "Canadianized" science-technology political emphasis? Perhaps some people became science teachers precisely because they didn't want to teach history and political philosophy but did enjoy helping kids to experiment and to provide explanations of natural phenomena. But now the goal is to nationalize what is international! Does this remind you of historians and politicians in the Soviet Union?

I am a strong advocate of meeting the needs of the students. The most obvious need expressed by secondary-school students in recent years is the need to understand the career implications of each course that they take in school. I encourage the discussion of technologies in the science classroom to provide students with insights into potential jobs. Students living in a lumber community in B.C. want to know more about the application of scientific principles in this industry, including the concept of the perpetual forest. You can think of many similar examples of the context for teaching students in a wheat farming area of Alberta, etc. Such "teaching in the context" is the requirement upon each teacher to make the topics relevant, to use local examples, etc. I am arguing in favor of placing science in the context of the students' lives. This is not the same as the political ambition of converting everything to building a Canadian identity to please the politics of Ottawa.

1.1.2 Frame of Reference

On page 7 you assume that a Canadian context for science education for the sake of a Canadian identity is desirable and necessary. I strongly disagree. This philosophical bias attempts to convert science education into the service of Canadian politics with little concern over the relevant educational needs of the students or the reasonable understanding of the nature of science. Such nationalistic politics is as much an imposition as the creationists' single-minded goal of re-writing science to fit their literal interpretations of the Bible. Career goals and local relevance are desirable and necessary. But Canadian identity is not an appropriate goal for the science classroom. It isn't even helpful in providing an understanding of the international competition that Canadians are facing from the technological advances of Japan, etc. In terms of economic competition, Canadians need to understand what other technological nations are doing and what Canadians must do to continue in this competition. Losing this technological race means sinking economically into the depression of British industries. This kind of understanding of science/technology is needed to make Canada a great industrial nation. Pretending that we now have many great scientists and need not look beyond our borders for models of excellence is politically narrow-minded, economically suicidal, and educationally immoral. On page 6 you mentioned that you were not seeking a consensus. You may not need everyone to agree with you but you should doubt the wisdom of your own central position. I am protesting that there is no science education wisdom in a Canadian context for Canadian identity. Although you have stated on page 7 that "the intent is not to be purposely nationalistic," please consider the prime advocates of that position and note that they are purposely nationalistic.

1.2.1 The section on "2.0 The Search for a Canadian Identity" on pages 8 to 17 condemns Canadians for a lack of nationalism. Meanwhile the European Economic Common Market and the European Senate move forward toward reducing the nationalistic and economic boundaries that have long prevented Europeans from reaching their potential of political cooperation and harmony, and of economic cooperation and growth. Why should Canada be moving in the opposite direction away from sanity and toward narrow-minded nationalism?

On page 10 there is mention of the Canadian value system. If you are really interested in defining the Canadian value system, I recommend that you study The Nature of Human Values by Milton Rokeach. He makes an analysis of some Canadian values on pages 89-93 and 153-154. As you may suspect, Canada has a mosaic of cultural attitudes and value systems. There is no Canadian value system!

In doing research on value systems here at the University of Victoria I have collected data demonstrating that our students have an extraordinarily low regard for the value of ambition. This is also common in other Canadian groups studied by Rokeach. Yes, Canadians seem to like their individualism (more than Americans and much more than Australians). The Canadian lack of ambition may be the key to understanding Canadian industrial expansion (or lack of same).

1.2.2 Nationalism and Internationalism in Canadian Science

On page 13 there is some discussion of Canadian geology. I note that many Canadian universities emphasize geography but few do much in geology. Yet Canada needs especially geologists. Geologists are often imported to Canada because they are needed and insufficiently trained here. Why not discuss career development? Explain why

Canada has the highest percentage of unemployment among the free industrialized nations of the West while simultaneously suffering extreme labor shortages in such fields as geology. Obviously, science teachers are not helping much in terms of meeting the personal career needs of the students. Such explanations put science education into a valuable context. Seeking the Canadian identity is questionable. Brouwer (1980) quoted on page 14 makes sense. The preceding part is contrary to Brouwer and does not make sense.

1.4.1 Content Components of Science Education in a Canadian Context

Starting on page 21 there is a request for interaction between Canadian Science and Canadian Society. The consistent problem is that most science teachers don't want to teach history, sociology, etc. Most social studies teachers refuse to understand science/technology sympathetically and limit their discussion of science/technology to abusive superficial attacks on dangers of mad scientists and uncontrolled technologies. I'm still looking for the social studies teachers who will reasonably present technology as it is known and practiced by most engineers. You are requesting that the science teachers must learn much about society. What burdens are you placing on the social studies teachers? If none, then the process has the ultimate goal of replacing time now devoted to teaching science, to the teaching of social studies within the science classroom with no compensation in the social studies classroom. At the bottom of page 24, the teaching of the history of Canadian science is aimed at the science teachers without even a mention of the history teachers. Why?

On page 26 you observe that Canada was unique in that the advance of science followed technology, etc. I don't believe this statement is true. Science in the U.S.A. followed a similar route simultaneously. The history of 19th century American "science" is mostly a listing of inventors of technologies, especially Edison, etc. The claim of Canadian uniqueness seems unsupportable.

The bottom of page 30 is most important. It should be a theme of science education as it already is the theme of scientists in their discussions with the public.

1.4.2 Methodological Components of Science Education in a Canadian Context

On page 32, item (i), if the content must be highly relevant to the students, then it must be quite localized and available for their experience.

On the bottom of page 33, there is a condemnation of regional "chauvinism" which might meet the students' demands for relevancy, might serve well the community's need for career development, and might allow local field trips, experiences, etc. This regionalism is condemned as a "problem" because it does not serve Ottawa's goal of using science education to serve the purpose of developing a Canadian identity. Therefore, Canadians in Ontario will study about salmon in British Columbia because this serves to build a Canadian identity. But Ontarians must not study about attempts to clean up pollution problems in nearby Cleveland, Ohio, because it is across the border. Yes, it has the same problems as found in the industries of many of Ontario's industries but examples must be limited to Canadian identities. The well documented environmental education materials about Lake Erie produced by the Greater Cleveland Council of Education are not Canadian and are regional. So we are building a

Canadian identity and not worrying too much about relevancy, students' experiences, etc. May I stop the sad list of conclusions and condemn the goal of seeking a Canadian identity. In its place, I advocate serving the needs of the students and promoting locally developed science courses, etc.

History of Science Professor (A2)

1.1.1 Defining the Problem

One must be careful not to confuse context with content--most do.

1.2.1 The Perceived Canadian Identity Crises

Ensuring a sense of internationalism combined with one of nationalism is a very important positive feature.

The argument moves in circles on page 10 since the fact that Canadians see nothing unique about Canada . . . is unique.

Is unrestrained individualism necessarily bad?

The U.S. value system is not any less dominated by capitalist considerations than Canada.

1.2.2 Nationalism and Internationalism in Canadian Science

It seems one must separate the method of science (which is or should be universal and apolitical) and the findings of science (or contributions to science).

Though I would agree that history and literature have much to tell us about who and what we are it is precisely because of their universality.

The point made by Brouwer on page 14 is a good one.

I don't think a uniquely Canadian context and the cultural role played by science necessarily go together. For example, there is an urgent need for students to learn about the impact of the atomic age on society. A certain amount of theoretical background is necessary for understanding (what is involved in the fission or fusion of atomic nuclei--certainly these are universal facts). If, beyond that, we were to emphasize only Canadian nuclear science we would find ourselves focussing on uranium mining and Candu reactors--and ignoring the nuclear arms race and radioactive pollution. This kind of one-sided view is not what I would like to see secondary school science teachers impart!

There may be a mixing of themes on page 16; I agree that science should be taught in relation to a social context but that isn't the same thing as relating it to national (Canadian) context.

1.3.1 A Case for Canadian Context in Science Education

Increased support for scientific ventures in Canada is a worthy goal, with which no scientist would disagree but you haven't made the case that it would follow from Canadianization of science teaching (maybe it has to come first).

It would be counterproductive if, in assisting students to cope with societal problems and pressures in part created by science, the effort merely reinforced the tendency to blame science for the problems of society.

The third point on page 17 seems a round-about way of saying (I think) that you want to encourage Canadian textbooks.

1.3.2 Definition of a Canadian Context for Science Education

One must not forget funding as an integral part of a Canadian context in science education.

1.4.1 Content Components of Science Education in a Canadian Context

The successes mentioned on page 25 which came largely from individual enterprise are not necessarily unique to Canadian science.

The belief that science was also a tool for the enrichment of mankind through development and exploitation of nature is an important theme, to be sure, but I would have attributed it to the industrial revolution thinking in all of western Europe.

Students must not only be able to understand the nature of both pure science and of applied science but also the difference between them.

I disagree that applied science serves as a bridge between science and society.

We should be focussing on finding ways to make pure science exciting and interesting and imparting some sense of humility with respect to "remaking the world to serve human desires."

The 'Science as Inquiry' content component of the perspective is a very important one.

The attitude mentioned on page 29 of the average person on the street not being interested in anything but the practical results of science may result also from not being educated in science at all.

Point (ii) on page 30 may be related more to economic policy than science policy.

1.4.2 Methodological Components of Science Education in a Canadian Context

We must not limit examples to local ones only--the problems are global, as are the implications of what we do.

When dealing with regional chauvinism one must be careful not to replace one chauvinism with another. One could reread the two sentences on the bottom of page 33 replacing 'Canadian' with 'world-wide'. Science teaching is too important to be merely a device for teaching nationalism.

2.0 General Comments

I thoroughly agree with your final point that the ultimate goal should be the education of scientifically literate members of society. I found myself reacting strongly where you seemed to be placing more emphasis on developing national identity than on science education in its own right.

I would also point out that it's important to distinguish between science and technology (while relating the two, of course). I sometimes think that if we could just teach students what good scientific method is, then they wouldn't fall for pseudoscience like creationism, or "Reader's Digest medicine"--nor would they be demanding ever-more energy-expensive products, at whatever cost to the environment.

Science Professor (A3)

1.1.1 Defining the Problem

I have deeper concerns over science education than the inadequate emphasis of Canadian context in science education. I should make the general comment at the outset that I am not overwhelmingly enthusiastic about an emphasis on the "Canadian context" for science education. Having said that, I believe that science educators should be able to use examples of the applications of scientific principles that are close at hand and meaningful to the students. Automatically then, science education in a Canadian school would have some Canadian context.

I am inclined to agree with the research conclusions of Norman Alcock, of the Canadian Peace Research Institute, that there is a remarkable lack of good nationalism in the world, and what starts out of good intention inevitably has bad results, e.g., the Symons episode.

I regard the 'Symon's Report' as a collection of homilies rather than research based upon evidence, and believe it to have been outdated upon publication. An important point is though, that the central role of instructional materials and their possible inadequate treatment of Canadian applications must be dealt with. One must also note that good teachers are not imprisoned by their texts.

1.1.2 A Frame of Reference

Canadian scientific enterprise and development of positive and critical attitudes towards science and its applications are not exclusive.

Improvement of the physical environment as included on page 6 is a very arguable objective.

I'm very happy you recognize that the notion of "philosophical treatments" included in a model for a Canadian context in science education can pose some difficulties.

1.2.2 Nationalism and Internationalism in Canadian Science

"Right on!" to the definition on page 12 of science as an activity . . . as much a part of the cultural fabric of a nation as it is a pillar of technology. Scientific laws may be universal:

scientific practice is not (i.e., application).

Science and Technology: one must be careful in switching back and forth between these terms; they are different.

The nut of the matter is contained in point (2) on page 13:

> "However, scientific knowledge is based on observation of things and events, and many Canadian scientists are indeed engaged in observing the Canadian environment. Even some of the investigative skills and associated technology employed in the scientific study of the Canadian scene obtain a national character. The O.E.C.D. examiners recognized Canadian uniqueness when they stated that 'it would be hard to find any country whose scientific structures and attitudes towards science are more clearly rooted in geography and history' (Hayes, 1973)."

Specific questions and problems that are posed by our land are contained in the application of science.

It is true unfortunately that as Peterson and others point out, science cannot flourish without scientists who in turn require a national organizational framework that will sustain and coordinate their activities, and an economic role to justify national financial support for their livelihood and work.

I must say 'Amen' to the view of Brouwer that since science has shown itself to be potentially at least an area in which men of all nations can work together, the Canadianization of scientific research and education must not be carried out for 'nationalistic' reasons but simply because science and technology can best show their value to all people if they are applied first of all in the local setting in which the research and teaching is carried out.

1.2.3 Identity Crisis in Canadian Science Education

On page 15, the attitude exhibited by some Canadians that they "could not care less" about Canada is more likely due to being provincial rather than internationalist to the core.

The first contributing factor to the lack of a Canadian identity in science education listed by Symons and Page that science seems rigidly disciplinary in orientation, consequently denying science students opportunities to learn about their country's history, politics, sociology, etc. seems like a flimsy argument in my opinion. The second factor, a lack of Canadian textbooks and excessive reliance on non-Canadian teaching materials in a broad range of areas is both true and false. There are many good materials, but seldom selected and apparently unknown. This reflects typical Canadian lack of market analysis and fulfilment.

The lack of texts being cited as a major problem is a consequence of the branch plant economy.

1.3.1 A Case for Canadian Context in Science Education

The fact that there are various educational systems in Canada is the problem. There is no Canadian educational system.

1.3.2 Definition of a Canadian Context for Science Education

The fact that there is no Canadian science policy is part of the problem being described.

1.4.0 Elements of Canadian Context in Science Curriculum and Instruction

What do you think would happen if the government of Canada set out to define, or even discuss the purposes of science education in Canada. Probably every premier would call an election to fight Ottawa.

1.4.1 Content Components of Science Education in a Canadian Context

Interdisciplinary Nature of Education sounds good, but needs a very careful analysis. The limits to interdisciplinary studies are very serious.

When suggesting through interdisciplinary studies that the whole can become greater than the sum of its parts, be careful, please. The mix had better be carefully done. Points (i), (ii), and (iii) on page 22 is apt to lead to a "wonders of science" approach.

When developing curriculum frameworks which allow integration within a Canadian context of what are now separate subjects in schools, the issue is: Who does the integration? The teacher? The student?

On page 26, "An economic base was created . . . This led to the rapid development of laboratory science" is the opposite to what has happened in the last 40 years. What period was Peterson talking about?

It is extremely important that students be able to understand the nature of both pure science and of applied science.

I agree that science definitely attempts to describe the world as it is while technology remakes the world to serve human desires and needs . . . it is the means by which humans adapt the environment to suit their needs. I also agree that of great importance to a Canadian context for science education is stressing the interrelationship of pure and applied science, so that emphasis is also placed on the concern that science be taught in such a way that issues of pressing national concern relating to science and technology receive a central place in the classroom experience of students.

It seems appropriate in referring to the curriculum to suggest that applied science puts science concepts in everyday affairs where the student confronts them allowing the student the opportunity to be aware of how applied science can be used to interpret critically what is taking place around him.

When discussing Canadian science policy it is important to note that there is no science policy in this country worth a hoot. There have been excellent proposals, some even implemented. Changes that have taken place, (iii) on page 30, have done so in my view, all without a policy. In Canada, science policy is merely whatever happens.

1.4.2 Methodological Components of Science Education in a Canadian Context

I am in full agreement with the maximum use of local environment outlined on page 31 that if students are to comprehend the relationship of science and technology in their lives, they cannot deal in abstractions alone. They must be able to relate abstract knowledge to concrete situations which they have encountered. It is therefore essential that the science teacher provide experiences and examples which will serve as concrete illustration and reinforcement of the science concept being learned. I also agree that students must develop a deep understanding and appreciation of the natural and social world in which they live. Therefore, science concepts should not only be illustrated constantly by concrete local examples, but the student should also be required to apply basic scientific laws and concepts to the study and understanding of his immediate environment.

Try to sell the point "the main thrust of science education in a Canadian context is that the students' knowledge and attitudes relate to all of Canada.

1.5.0 Conclusions

In response to the conclusion: good luck/if there is a Canada!

2.0 General Comments

In addition to the marginal notes, I wish to comment on three general issues:

(1) I urge you to be careful in the usage of the terms science, applied science, and technology. There are good sections in your paper, but also I believe some areas open to interpretation.

(2) If there is to be in science education a proper consideration of the application of science, then teachers must be expected to and able to apply the scientific principles they are talking about to their immediate environment. If this condition is met, hand-wringing about whether or not there is a Canadian context becomes largely irrelevant. To illustrate, at universities, there is little in our science course descriptions that emphasizes Canadian content, but look at the research interests of the professors as indicated in university research inventories. It is inconceivable that these professors could teach science other than in a Canadian context. Teachers in the school systems must realize the importance of and be given the opportunity to prepare themselves in this way, even though they haven't the time and background of the professors.

(3) If I had to build into the constitution of a country a sure-fire self-destructive mechanism, it would be to divide the jurisdiction for education into several separate parts in order to be sure not to have a national office of education! The historical reasons for our current educational predicament in Canada are well-known. Never-the less, without a national education office, how can we ever expect our diverse educational systems to generate a proper Canadian context for anything? In my opinion, this is the root cause of many of the educational problems in this country, as well as some of the major social and political divergences we are now witnessing. So far as a Canadian educational system is concerned, there is none; only a potpourri of provincial systems.

Science Education Professor (A4)

1.1.1 Defining the Problem

Who determines the conceptual interpretations and messages which are warranted for use in our Canadian schools, referred to on page 4?

1.1.2 Frame of Reference

When referring to applications with appropriate local, national, and international emphasis, what is appropriate?

On page 6, ". . . fostering an ability to understand and respond to change . . ." reflects a particular philosophy. A person should be able to determine change, not only respond to it.

Canadian identity may not be a philosophy, instead may be a criteria.

1.2.2 Nationalism and Internationalism in Canadian Science

I'm not sure what national character means if science done in Canada by Canadians is not Canadian. Are you saying that only science which can be done in Canada and no where else is Canadian?

Science has a significant impact on economic, technological, political and social aspects of Canada but it works both ways.

1.2.3 Identity Crisis in Canadian Science Education

You seem to be setting up straw men by saying "If there indeed is an identity crisis in Canadian science education . . . "

1.3.1 A Case for Canadian Context in Science Education

On page 18, ". . . the needs of Canadians and Canadian society . . ." cannot be discussed without elaborating on who is determining the "needs".

Discussing reducing "disparity" really doesn't mean much since you are assuming a disparity exists, but who know what this "disparity" is?

1.4.0 Elements of Canadian Context in Science Curriculum and Instruction

The term effective citizenship is a dangerous term that needs to be defined.

1.4.1 Content Components of Science Education in a Canadian Context

On page 22, point (i) could include the effect of society on science and technology.

Besides the variety of roles that high school students as adults will play in Canadian society in the future and how science can prepare them for those roles, attention should also be given to the roles they are currently playing.

Implications of Canadians being ignorant of many important Canadian achievements are obvious only if one accepts the arguments used.

Presenting science in a Canadian context implies a particular view of teaching. Is it possible to convey pride?

1.4.2 Methodological Components of Science Education in a Canadian Context

A great deal is assumed in stating that having students deal with topics and problems of current local scientific significance will help to develop in students a commitment to the careful use of natural resources in Canada and to the preservation and improvement of their environment.

Science Education Professor (A5)

1.1.2 A Frame of Reference

It is imperative to define the terms Canadian context and Canadian identity explicitly.

1.2.2 Nationalism and Internationalism in Canadian Science

Saying that science has more that is new to tell us about who and why and what we are than any contemporary branch of human knowledge does not necessarily support the claim that science is very much a part of the culture of a country.

1.2.3 Identity Crisis in Canadian Science Education

When speaking of a social context, must it be Canadian or could it also be international?

1.3.2 Definition of a Canadian Context for Science Education

In describing the specificity of Canadian context on page 19, the result is a very odd connotation. Does this mean that "Canadian context" includes only those issues in which Canadians are unique, and, therefore, excludes all issues in which we have a commonality with those of any other country? Must consider why uniqueness contributes to identity.

1.4.0 Elements of Canadian Context in Science Curriculum and Instruction

The statement on page 20 noting that a Canadian context for science education indicates a need for open discussion of the goals and purposes of science education in Canada seems predetermined by the preceeding twenty pages!

1.4.1 Context Components of Science Education in a Canadian Context

The objectives of interdisciplinary study listed on page 22, worthwhile as it is, very little of this strikes me as amenable to a unique Canadian setting. Rarely are we after Canadian examples of what are essentially international phenomena.

When considering the philosophy underlying Canadian science, one must consider whether there is a specific philosophy guiding the work of any scientist.

The evidence quoted from Peterson in support of the uniqueness of Canada on page 26 is accurate for most of the developed world, not just Canada.

There is more to content than learning science by inquiry.

The attitude of the average person not being interested in anything but the practical results of science is more likely because the average person cannot comprehend theoretical constructs and abstractions.

2.0 General Comments

You have overstated the uniqueness of Canada, I think. You have presented an excellent argument for teaching science in a social context, but most of the time, your argument would be unaffected by removal of the word "Canadian". The curriculum needs to include the history of Canadian science, and examples of contemporary Canadian science, but a lot of what you seem to be asking for looks international to me.

Perhaps my concerns would be alleviated if you substituted "important to Canada" for "unique to Canada".

Science Curriculum Professor (A6)

2.0 General Comments

Inevitably, the big issue will always be the interaction of international science on Canadian students. Lay people will not make the distinction (nor, indeed, do I feel that they should) between international and Canadian science. Jingoistic pride in Canadian achievements is inevitable, but that won't help much in bridging the gap between the "two cultures".

Concentrating on Canadian examples makes good pedagogical sense, especially in the study of subjects such as geology or crop science. This does not lead to a belief in an inherently Canadian science. In other words, I guess that I am not very sympathetic to the view on p. 26, last paragraph of 4.1.4.

Science Education Professor (A7)

2.0 General Comments

Just a detail on p. 32, Physics: A Human Endeavour belongs in section 4.2.3 and not 4.2.2 where it is. They rewrote Harvard Project Physics, and rather badly at that I think.

Science Education Professor (A8)

2.0 General Comments

The paper is well thought out and very well written, especially since it was necessary for you to go well beyond the immediate field of science education for your starting point.

Doug Roberts' notion of "clue structure" is a quite appropriate concept for the task at hand. However, I am not sure that the paper explains this concept sufficiently well. In particular, the paper does not explain the process involved in the search for a clue structure and how this extends beyond an ordinary analytical literature review.

The components of the Canadian context seem to me to be quite adequate and exhaustive. I do question the inclusion of "science as inquiry" (4.1.6) as an element, however, since methods of inquiry is perhaps the most universal characteristic of science. It might be better to elaborate more on the socio-political aspects of the context of scientific inquiry rather than to inquiry in itself.

In your concluding section you refer to analysis of ministry of education documents, although the earlier discussion seems to suggest that your application of the clue structure would be to a broad range of instructional materials. I would hope that your ultimate analysis would extend to textbooks, teaching guides and similar documents since these are likely to be much more revealing than ministry guidelines and the like. Also, the concepts you have delineated could well be applied to teachers' treatment of science. There may well be a great difference in "Canadian Context" in what teachers actually do as compared to what the documents say. This, of course, would be too much to ask of a Master's thesis. Nevertheless, the point probably should be addressed.

Some of the work now being done by Graham Orpwood and his associates in the Science Council's study of science education looks similar to what you are suggesting. I believe, for example, they plan to engage in document analysis from the perspective of examining the Canadian context of science curriculum. Perhaps your work is connected with this, since I understand that they have been seeking assistance from graduate students and other science educators. If not, it might be worth taking a close look at the current status of the Science Council's study.

Secondary Education Professor (A9)

1.1.1 Defining the Problem

Another viewpoint regarding O.E.C.D.'s conclusions is that of Lionel Orlikow who presents an interesting view of Curriculum Decision-Making in Canada in McGill's Journal of Education, 1981, XV1, 3.

Canadian Science. How does it differ from the scientific activities conducted throughout the rest of the world? Canadian context needs to be defined. I assume it means environment though it also refers to meaning. If context is replaced by environment then your study is concerned with environmental education. To the extent that one wishes to improve "the amount and quality of Canadian context in our science curricula" it is essential that we clearly understand the meaning of the term.

I am concerned that Page's 1979 article may lack the scholarly substantiation one likes to utilize as a foundation for a worthwhile study. From personal experience, I am aware that Stat's Canada, Ottawa, are most concerned that good research methodology is essential for worthwhile results and acceptable conclusions. In order for me to use Page's article as a base I must know its scholarly acceptance as being valid. In this case I must know the composition of the colloquium: How the members were selected? In particular: Were they randomly selected? Were all areas of Canada represented? Were all areas of the scientific community? It is necessary for me to know the specifics of the colloquium that influenced Page to write what some have labelled, a society biased article. My own historical survey of the literature of the past 100 years has shown that discipline-societal-humanistic influences are periodically exerted on science curricula. Having just witnessed discipline oriented curricula such as I.P.S., B.S.C.S., P.S.S.C., and CHEMS., we now see societal values competing with those of the humanists as a major influence on curriculum development. Now back to your study:

Page's number (ii) reflects an international concern presently being attended to by U.N.E.S.C.O., The International Council of Scientific Unions, and many other groups of science educators around the world. Known as the s^2t curriculum (science, society, and technology) it is concerned not only with the local environment but is related to global issues too. I am concerned that you stress "A Canadian Context for Science" and omit Page's and international science educators' concerns for technology and society's culture. This omission, along with your emphasis on Canadian science and identity problems on pp. 9-11, suggests nationalistic values inherent to the international s^2t programs. If this be so, then you are using the quotes of international scholars concerned with s^2t curricula out of context and this needs to be remedied.

1.1.2 A Frame of Reference

You reiterate some of the concerns expressed in international

s^2t curricula which suggests to me that your study is intended to deal with s^2t elements in Canadian science education. There appears to me to be a need to clarify your intent in this matter. You have mentioned the identification of Canadian science, science teaching, science instructional materials, Canadian ideas (presumably science) but at this stage I am not sure what you are really looking for.

N. Frye--a good quote from a highly regarded scholar but I'm not at all sure that his expressed concern is relevant to Canadian science education.

1.2.1 The Perceived Canadian Identity Crisis

Whilst you initially deny any intent to be purposely nationalistic (p. 7) you then confirm my suspicions that it is a nationalistic study making use of global s^2t curriculum issues.

You now mention "science education must be rooted in a Canadian dimension of our science and technology". No emphasis has been placed on technology previously as it has been for Canadian science.

1.2.2 Nationalism and Internationalism in Canadian Science

Whilst mentioning "widespread belief that science is universal" and it being "inappropriate to speak of Canadian science" you then give greater credence to the Symons Report without substantiating--in more depth--the reasons for pushing their widespread ideas aside. Why bother introducing another question as to which is the most valid viewpoint of mankind for science when it does little--if anything--to substantiate the reason for your study.

Why do you use Trainor's definition of science? Is it highly regarded? If so, by whom? The following sentences suggests that it is closely related to society and technology, yet you have only emphasized Canadian science up to this point. You change this later to Canadian context for science education pp. 18, 19...

1.2.3 Identity Crisis in Canadian Science Education

Re. Hodgett's claim 'can have a very detrimental effect on science education in Canada ...' I disagree. Inasmuch as fish and birdlife in Antartica have been found to have a high D.D.T. content in their systems that can be traced back to spraying in N. America, such knowledge really drives home the problem re. the use of D.D.T. in Canada. I also believe that all knowledge is relative and as the world's problems impinge on Canada today I wonder about the validity of Hodgett's 1968 work in your study. Particularly, when later on (p. 21-) you get into the interdisciplinary nature of education and elaborate on such needs on pages 23-24.

"As has already been indicated"... This is a strong statement. What is in the curriculum is not necessarily what goes on in the classroom. I would like to know much more about this study. Did it use random sampling for every area of Canada, number of respondents, validity of questionnaire used, results obtained? Remember, the use of a study that the likes of Stat Canada considers poor or worthless, can be detrimental to your own study. In this respect I would be loth to use Page's work (p. 17) in Ontario to generalize to the rest of Canada.

The problem concerned with the lack of Canadian textbooks has during the past 30 years, to my knowledge, been one where, in many instances, other areas of Canada were told by publishers "If it cannot be sold in Ontario the text is not financially viable." Ontario insisted on using made-in-Ontario texts so it was much easier for Canadian educators outside of Ontario to go elsewhere for reasonably priced texts, and they did.

1.3.1 A Case for Canadian Context in Science Education

At this moment in time, due mainly to the methodology used to substantiate the Science Council's printed materials, I would refrain from using it in scholarly research work. I am also sure that Stats. Canada would say that it cannot be generalized to the whole of Canada. Your conclusion on p. 18 regarding the responsibility that all Canadian Sc.Ed's must assume is a motherhood statement. How about the non-science teachers who may be in the interdisciplinary education team mentioned on pp. 21-22? The problems that evolve in interdisciplinary education are of an epistemological nature that are difficult to overcome.

1.4.1 Content Components of Science Education in a Canadian Context

Why are you so concerned about science as inquiry when the type of interdisciplinary curriculum mentioned earlier makes use of a great variety of methods including decision-making mentioned on p. 24.

2.0 General Comments

In general, there is a need to tighten-up your usage of terminology and to clarify what exactly you intend to investigate. Whilst initially, you refer to Canadian science, I feel that you really mean science education, and in this respect I am not sure that I am happy with the usage of the term context. Also, as your paper progresses you move away from a nationalistic viewpoint of science to a Canadian context for science education to a Canadian Science-Canadian Society interaction where you consider most of your ideas outlined in international s^2t curricula. It seems to me that you would profit more from your scholarly investigation if you collected data relative to the international s^2t scene then identify those elements of it that are present in, or omitted from Canadian science education. This is a logical development from the O.E.C.D. judgement of our science education and the fact that scientific work undertaken in Canada is also judged at the international level.

In this respect I recommend that you strengthen your bibliography with recognized scholars in the fields of curriculum studies and science education, particularly those whose work supports s^2t curricula. Inherent to such curricula are societal-humanistic values therefore I would refer to the work of Florence Stratemayer, Hilda Taba, D. Walker, Dewey, Zais, for societal reasons, and Sergiovanni & Starratt, Weinstein & Fantini, Paulo Friere, and others for humanistic concerns. Dr. W. Williams of Leeds Un., U.K. would also provide you with some valuable international materials to serve as a base to identify the s^2t curriculum concepts that are peculiar to Canadian science education.

A review of the N.S.S.E. yearbooks for science will reveal that the concerns expressed in your paper have been around for a long time. They will reveal that the last time societal issues in science were emphasized was during the nineteen forties and early fifties when teacher training gave emphasis to teaching science accordingly. There is now a greater urgency throughout the world for a curriculum dealing with s^2t for the benefit of mankind. The fact that you are prepared to undertake an investigation associated with such concerns in Canadian science education should make a valuable contribution.

In closing, I must refer again to Orlikow's article which depicts the problems associated with Canadian curriculum development in all their glory. Inasmuch as education is a provincial matter, and governments protect this jurisdiction most fiercely, it is not possible for Canadian science education to assume the responsibility for the identity crises you outline on p. 18. Teachers are required to work within the constraints of provincial curriculum guidelines and at present have little opportunity for redressing the neglect mentioned throughout your paper.

Science Education Professor and Science Textbook Author (A10)

1.1.1 Defining the Problem

The fact that few Canadians could name a Canadian scientist could, of course, mean that Canadian scientists have made few major contributions.

The O.E.C.D. conclusions that Canadians not only tolerate modes of operation that non-Canadians would feel were intolerable but accept them happily because they feel that most things have gone along quite well is true in my experience.

When discussing the central role of instructional materials and their possible inadequate treatment of Canadian science, it must be considered that the bulk of science (basic laws, models, etc.) knows no boundaries of geography or culture.

The practice of adopting American curriculum projects is not true in Ontario. American programs have virtually vanished in our K-12 continuum. Books written by Canadian authors are used in most schools. I see a definite trend in this direction in many other provinces.

It is important to distinguish between those conceptual interpretations warranted for use in Canadian schools and those which are not for it is true that the approach used to convey a science concept affects a person's understanding of the phenomenon being studied.

We do need to teach more than facts, formulas and structures but we cannot ignore these, as Suzuki also suggests from time to time. One cannot think or apply information with an empty brain.

1.1.2 A Frame of Reference

When discussing the Canadian scientific enterprise, other than "history", does it really differ from other countries?

Your inclusion in the theoretical perspective of careful use of natural resources in Canada and commitment to the preservation and improvement of the physical environment is good.

1.2.1 The Perceived Canadian Identity Crisis

It is true that Canadians lack a clear-cut overriding identity which sharply defines their national character and the national self-awareness that does exist is low key and often unconscious.

As well it does seem that Canada's toleration for foreign control and influence over its economy and culture is unique. This may explain why members of the mass public tend to lack realism about the character and severity of the country's economic, cultural and political difficulties.

1.2.2 Nationalism and Internationalism in Canadian Science

In the discussion of whether there is a national as well as an international dimension to science I support the view that science is universal in nature and should not be restricted by national boundaries and considerations, up to the point where one brings to apply the knowledge to uniquely Canadian affairs such as environmental quality in the North, pollution of pre-cambrian lakes, etc.

Scientists certainly don't behave as though science is an activity which involves people, attitudes, aims and processes.

Science may have more to tell us about what we are but it may not "tell us" that we are Canadians.

I agree with your summary on pages 13 and 14 of the national versus international character of science and certainly hope that there is a blend of national and international components in the field of geology.

1.2.3 Identity Crisis in Canadian Science Education

A Canada-centered approach could damage severely the important connections and understandings that may ultimately get this world working as a unified whole. My car is Japanese. My camera and calculator are Japanese. My T.V. is Japanese. That's because they are of higher quality (so judged by Canadian C.A.C.). As a result, I am very interested in Japanese science, technology and culture. It has things we don't have. Why should we push an inferior Canadian context? A world view is most important to me. I want the best and I want to teach the best, whether it be Canadian, Japanese, or Russian (even American!).

As for your point that science-society interaction is virtually absent in science teaching in Canadian schools, try writing a curriculum document or text that dares to tread into the societal realm. I have. They are severely attacked by reviewers at the manuscript stage. Most government education ministries and schools seem to want content and little more.

I discount Suzuki's comments on schools. He neither teaches nor visits schools. A few days ago he fell asleep during a presentation by the Science Teachers' Association of Ontario to the Science Council of Canada. And, believe me, it was an outstanding and important presentation.

I believe science can be intrinsically motivating. It should, of course, also have practical applications, when possible.

Page's description of a review of curriculum guidelines for Ontario elementary and secondary school science courses can definitely not be considered representative of other areas in Canada. Page is out of date! Non-Canadian texts are rare in Ontario. Has Page looked at recent documents? The forthcoming "Environmental Science" document lists about 30 Canadian books for student and teacher reference.

On the point made by Page that teachers have little or no training in "Canadianizing" their science curriculum, neither Page nor the Ministry visited our faculty. It is true to some extent that science teachers feel pressured to prepare their students for undergraduate work at the university level and, therefore, consider themselves under time constraints that they do not bother with relating science to the Canadian context.

Page's statement that the important point is the lack of texts was cited as a major problem is definitely not true. This is a serious misrepresentation of the facts. Don't hold too much by this. Even in Alberta my books out-rank American books in usage for some courses.

* * * * * *

To support the point regarding the availability of Canadian texts in Ontario, excerpts of the Ministry of Education, Ontario, Circular 14, 1981 were enclosed with the respondents comments. In these excerpts the respondent had identified "Canadian" materials.

In the area "Science, Intermediate Division, 1978 (I54-040) of 82 books or series listed, 66 were identified as Canadian. Comments by the respondent indicated:

(a) Biological Science: An Introductory Study, William A. Andrews et. al. Prentice Hall, 1980 was used in nearly all schools in Ontario as well as many other provinces.

(b) Physical Science: An Introductory Study, W.A. Andrews, T.J.E. Wolfe, and J.F. Eix. Prentice Hall, 1978 is used in 90% of Ontario schools and in several other provinces.

(c) Though not included in the previous figures, most of the French books and series are also Canadian.

In the area of "Biology RP-50, 1963 (S50-010) of the 16 books or series listed, 14 were identified as Canadian.

In the area of "Chemistry RP-51, 1965 (S51-020) of the 15 books or series listed, 8 were identified as Canadian. As for "Chemistry S.17D, 1966 (S51-030) of 20 books or series listed, 19 were identified as Canadian.

The area of "Physics S.17A, 1966 (S55-010) of 15 books or series listed, 15 were identified as Canadian.

* * * * * *

1.3.1 A Case for Canadian Context in Science Education

Even if Canadians are able to deal more effectively with Canada's future, Canada's future is unalterably connected to most of the world. Let's not get too parochial.

I agree that in order for Canadians to use science creatively to solve problems in Canada, they must obtain a holistic view of the nature of science and its relation to Canadian society.

If a Canadian context allows Canadians to make a realistic assessment of the potentials and limitations of science for resolving serious problems in Canada, this could in turn lead to increased or decreased support for scientific ventures in Canada--if our ventures continue to be plagued by current problems.

In assisting students to cope with societal problems and pressures, a world context is even more vital in this respect, e.g., acid rain, considered mainly from a Canadian context, gives a myopic view indeed of the real causes, effects and potential controls.

1.3.2 Definition of a Canadian Context for Science Education

I like the idea of letting science move beyond content and scientific processes. This is vitally important. Most scientists, I suspect, would not agree.

1.4.1 Content Components of Science Education in a Canadian Context

In response to the point that even highly educated Canadians are almost totally ignorant of many important Canadian achievements in science, I believe there is little to know. We haven't shown much leadership in science and technology. The impact that science and technology have had historically upon Canadian life has seldom been Canadian.

The history of Canadian science is deadly! I would hate to teach it!

If a student is presented science in a Canadian context which includes significant historical achievement, I doubt if a sense of Canadian identity and pride will be conveyed. It will be viewed as just one more fact to know.

With reference to applied science on page 27, unfortunately the "applied" part may be out of date tomorrow. We cannot skimp on basic principles or students will be unprepared to adapt to the applications of tomorrow.

The point in your science as inquiry section that students be given opportunities to apply inquiry strategies when dealing with pressing Canadian problems which require a scientific/technological solution is an excellent example of the need for a Canadian context, along with appropriate global content.

1.4.2 Methodological Components of Science Education in a Canadian Context

In listed locally-produced materials you have listed several that have made a minor international penetration. There are others that have a major international recognition.

There is no indication that foreign materials will continue to be used in Ontario in the foreseeable future. It is viturally impossible to use a foreign science text in Ontario. Economies of scale of production are not necessarily derived by selling instructional materials on an international market. A good Canadian book is a money-maker, even if it sells only in Canada.

You are right in stating that the main thrust of science education in a Canadian context is that the students' knowledge and attitudes relate to all of Canada with no room for regional "chauvinism".

Science Curriculum Professor (All)

2.0 General Comments

First, I want to say how much I enjoyed the paper. Not only is it interesting, well argued and pointed; it is also well written. Next I should say that generally I am sympathetic to what I think you are trying to do, though I am a little unsure of how a clue structure comes out of what is argued in the paper--I take it that that issue gets resolved in later work. Now to some more substantive points.

I had some difficulty at first with the idea that it was important for Canadian students to know something of Canadian science and scientists. On reflection and further reading, I think I know the source of my difficulty: A clue structure, like the ones developed and used by myself and colleagues, falls out of what we have obviously considered to be important, though it itself does not advance that position. Let me try to explain. In Seeing curriculum in a new light (Munby, Orpwood, and Russell, OISE press) I have a chapter on intellectual independence in which I say, essentially, "Here is a different way to look at classroom discourse". I don't say "Here is the only way", nor do I urge that all classroom discourse should aim for intellectual independence (though I may happen to support that view). So, the way I see your paper is as advancing the case for Canadian content (as it were); whereas I think the clue structure ought to be saying "If Canadian content is important, then here is a way of looking for it or dealing with it". Okay?

Your position is very clearly stated in the conclusions on p. 34. Here you are urging for Canadian content--please pardon the phrase, but it does the job for this communication! I tend to think that your position ought not to feature in the development and use of the clue structure, though it gives rise to the study that you are undertaking. A way around this problem is to make it clear (as you almost do) that you are dealing with a stated aim of science education in Canada, and then to show the reader what is involved in that aim, as I think you have done. It is then for the reader to determine whether or not your study is significant enough to warrant action, and he may take this decision on the basis of the arguments you cite, rather than upon a position you take.

Now, why do I think that that is important? First, I think, because I don't think the Canadian identity is an issue; and secondly, because I believe that there are other important (if not prior) aims for science education in Canada. Let me expand on both.

Northrop Frye's comment is lovely, and he's right. Have you ever heard of a U.S. or British citizen speak of their identities? I think the answer is no--that's presumptuous, I'll just say it is no for me! The point, though, is that the quest for a Canadian identity seems mythological. Someone once said (and it could have been Frye) one does not search for an identity, one has one. Canadians have an identity. The issue is whether they know it and like it. (Incidentally, I can't see any reason for a country to have an identity, especially if that country is so geographically, economically and politically diverse--to say nothing of ethnicity. I would be hard pressed to give an account of the U.S. identity, but I might hazard one for Austin in Texas, and for Houston--they would be different as would my picture of New Orleans, Florida, and so on.) Of course, you can still tie your work to the search for a Canadian identity, because that is on the minds of many you have cited. Yet, I think it might be unwise to lock the thesis to the search. (Perhaps there are no holy grails!)

Aims for science education in Canada: Yes, much of what you have said about young Canadians learning about the economic, social, technological, and political aspects of science are important. In fact, I tend to put that sort of thing above many other science education goals. So, while I agree with much of what goes into your fourth section, I find it hard to swallow in the context of a Canadian identity. In brief: the identity crisis is an illusion. Instead, we have an education crisis in the form of curricula which appear not to inform our young about the political, historical, economic and social context of science in Canada. Now, what I think is worth noting about the last sentence is how it clearly corresponds to much of what you have said _without_ calling up the mystical identity crisis!

Elementary Science Education Professor (A12)

2.0 General Comments

The basic ideas look O.K. to me.

Science Education Professor (A13)

2.0 General Comments

I get the impression that you are basically talking about secondary, i.e., especially high school science.

Are there any points with regard to broad conceptions of "scientific literacy" as a part of general education, i.e., for the range of students in schools, many of whom never see high school chem/physics. I think here again one has to be careful of the _ideal_ of an individual who has an understanding of science in a Canadian context. What would this person's conception be like? Is the ideal even partly attainable? Sort of a Canadianized version of the "Renaissance man?" "Woman?" In whose interests is this position, the student, the establishment, the society, etc.?

Science Professor and Science Education Professor (A14)

1.1.1 Defining the Problem

I have a sneaky "regard" for the Canadian type of tolerance outlined by the O.E.C.D.

1.1.2 A Frame of Reference

The section outlining the important issues or elements associated with the notion of Canadian context in science education (page 6) is good.

1.2.1 The Perceived Canadian Identity Crisis

You must be careful in suggesting that Canada has encouraged takeover of its resources and mind. The judgement concerning members of the public lack of realism about the character and severity of the country's economic, cultural and political difficulties seems to have no supporting proof.

1.2.2 Nationalism and Internationalism in Canadian Science

Much of Canadian geology has been done by Americans.

1.4.1 Content Components of Science Education in a Canadian Context

Whose holistic view of man are you referring to in the "interdisciplinary Nature of Education" section.

There is a question of when some of these topics ought to be introduced into science. Not all, in every grade of high school, in every course, etc.

2.0 General Comments

Your paper presents a well-balanced overview of the problem and a reasonable approach to its solution. Strangely enough, it will not be internationalists who will disagree most, but it might be the regionalists. Moreover, education alone, or awareness of the problems, is not a guarantee that Canada's problems will be solvable.

Science Education Professor (A15)

1.1.1 Defining the Problem

It is true that major concern has been expressed over the inadequate emphasis of Canadian context in science education.

It is also agreed that science instruction can become a vehicle for Canadians to add another dimension to their national identity.

1.1.2 A Frame of Reference

Yes, Canadian context for science education does become philosophically acceptable within the context of Canadian identity.

1.2.1 The Perceived Canadian Identity Crisis

Agreed, it is of concern to analyze the identity question in Canadian science.

1.2.2 Nationalism and Internationalism in Canadian Science

I am certainly of the view that science is as much a part of the cultural fabric of a nation as it is a pillar of technology and that scientific laws may be universal but scientific practice is not.

It is also true that the question of Canadian identity does not seem to reach the same critical proportions in science that appears evident in other spheres of Canadian life.

1.2.3 Identity Crisis in Canadian Science Education

Amen to the fact that there is a well-founded catalogue of neglect in Canada in scientific research and teaching. The unparalleled story of neglect and missed opportunities in science education is still true today unfortunately.

Because social context is largely absent, the majority of Canadian society is alienated from science and hence the need for public awareness of science.

1.3.1 A Case for Canadian Context in Science Education

The Science Council's colloquium statement that adequate recognition of a Canadian context for science education be a basic educational objective is very important.

1.3.2 Definition of a Canadian Context for Science Education

As a methodological component in the pedagogical strategy of presenting a Canadian context, Canadian written textbooks must have an emphasis on discoveries made by Canadians.

1.4.1 Content Components of Science Education in a Canadian Context

Yes! The history of Canadian science must be included in science curricula to develop in students an awareness and appreciation of the role of Canadian scientists and technologists in Canada's growth and development. It is true that Canadian context including significant historical achievements can convey a sense of Canadian identity and pride.

1.4.2 Methodological Components of Science Education in a Canadian Context

It is very important at all levels that students be able to relate abstract knowledge to concrete situations which they have encountered.

Instructional materials must include wherever relevant, information on Canadian science, scientists and the Canadian science-society interrelationship. This also needs to be up-to-date. There is also a need for French language adaptations not merely translations.

2.0 General Comments

There has been no mention of languages--French and English.

B. Canadian Science Teachers' Reactions

Science Teacher, Graduate Student, Science Textbook Author (B1)

1.1.1 Defining the Problem

ALCHEM does not rely on American or British models.

The Symons Report reflected universities only. The school report was never published--considered too political or something. It was written by Symons but not published. Page's identification of the failure of Canadians to recognize that science and technology are integral parts of our society's culture refers to Canadians in university liberal arts programs. The lack of attention to Canadian dimensions and problems in science teaching and research is meant at universities.

No amount of U. of (?) papers will solve the possible inadequate treatment of Canadian science and the central role of instructional materials.

Abstract facts and concepts must be presented in a manner which allows the student to view them as relevant in their cultural and physical environment among other contexts such as epistemology reconstruction, ethics, etc. Delimitations are not clear. A Canadian context is just one type of context as well as being only one Canadian context as determined here.

1.1.2 A Frame of Reference

A theoretical perspective is used to explain and predict if you believe in the scientific paradigm. Who evaluates the theoretical perspective?

The elements outlined as being associated with the notion of Canadian context in science education are typical.

All knowledge is 100% biased.

1.2.0 The Search for a Canadian Identity

Everybody is already teaching science in the social context. That's the problem. They need to step outside the social context and see what they are doing.

1.2.2 Nationalism and Internationalism in Canadian Science

To show a Canadian context in science education rooted in a Canadian dimension, examples would help e.g., acid rain.

The widespread belief that science is universal was defined in chem. ed. by physical chemistry types from California in 1958-62. It assumes no bias--a 19th century view of science.

There is science which in a broad non-nationalistic sense includes discovery of scientific laws and development of scientific theories within current contexts. There are also underlying methodologies of scientific inquiry which are universal for the time.

Science may be international (I don't agree) but science education is not. Science and science education keep getting confused. There are places where they overlap but they are not equivalent.

1.2.3 Identity Crisis in Canadian Science Education

The lack of texts cited as a major problem by Page was directed at Ontario universities.

1.3.2 Definition of a Canadian Context for Science Education

Canadian context is a context, not "all" contexts. There are other things to value than Canadian context.

Pure and applied research pertains to science as opposed to theoretical and applied knowledge in science education.

1.4.1 Content Components of Science Education in a Canadian Context

The problem is with integration. It is the wrong approach. Integrating won't integrate, other strategies will.

Philosophy underlying Canadian science is my favorite section so far.

There is theoretical science education and there is applied science education--to use old fashion words.

The average person on the street not being interested in anything but the practical results of science is partly a result of the way we teach science as inquiry.

1.4.2 Methodological Components of Science Education in a Canadian Context

Core-elective format sweeping Canada is totally ignored.

In dealing with foreign instructional materials do not bother with teachers' guides--no value.

1.5.0 Conclusion

Not only will there be a majority of scientifically-literate Canadians but also Canadian teachers.

Science Teacher, Science Textbook Author (B2)

2.0 General Comments

Agree with the basic ideas put forward. An attempt must be made to contact individuals integrally involved with production of local materials in order to get a true perspective.

Elementary Science Teacher and Graduate Student (B3)

2.0 General Comments

Tend to agree with the theoretical perspective put forward. My own research seems to reflect an implementation of your perspective to some degree.

Secondary Science Teacher and Graduate Student (B4)

2.0 General Comments

Unfortunately, the lack of Canadian identity, I think, can only be solved through politics and the media. The media's report on the Canadian arm on the space shuttle probably did more for our identity than textbooks can ever do. Any progress in education will have to come from educators and teachers in the classroom working from grade 1 up or by those willing to spend the time to write new material such as the ALCHEM group. Until governments feel the need for Canadian content, little funding or incentive for those interested will ever arrive. Alberta's government is interested in Alberta content but this is a narrow outlook and could disappear with the next election.

Science Teacher and School Board Supervisor of Science (B5)

1.1.1 Defining the Problem

Problem in what sense? There is a presumption here that lack of understanding of Canadian scientific endeavors and of Canadian scientists is a problem, but there is no rationale given as to why this should be perceived as a problem, i.e., so what? So what if most kids don't know any Canadian scientists. How does this adversely affect those students' development as individuals? How does this adversely affect society? If we were to learn that 99% of all Canadians could not name any of the moons of Saturn would this be a problem? What is your criteria for calling something a problem? Innuendo is not argument. What is needed is some kind of theoretical/ philosophical basis for interpreting these facts which you suggest are indicators of a problem.

If we have to adopt the "blame" concept, then let's not blame the teaching as such. Rather, focus in on the curriculum as defined to the teacher. Let's also focus in on curriculum resources.

Is it to be taken without question that a national identity concept is desirable? What is "national identity" anyway?

1.2.0 The Search for a Canadian Identity

What is identity? . . . a name? A set of distinguishing characteristics? What are we talking about? How about identity as consisting of common purpose; a common code of behavior and a common way of interpreting social events.

1.2.1 The Perceived Canadian Identity Crisis

What is meant by identity crisis? What meaning does this expression have outside of popular psychology? A value system dominated by acquisitive and materialistic considerations is your basic Canadian identity.

1.2.3 Identity Crisis in Canadian Science Education

Hear! Hear! Full agreement that the present emphasis on the changing nature of society, on the resulting doctrine that all knowledge is relative and that it does not matter what we teach, is one of the most damaging ideas in Canadian education today.

Presenting science education as being the discipline concerned with the interface between science and society is good stuff.

Yes! There are very few Canadian texts as suggested readings for students and the guidelines do not reflect a Canadian context other than in the most perfunctory way. How about the lack of imagination and courage on the part of Ministry of Education officials as another cause? We really do have the capacity to write our own materials, not just write in Canadianization as some type of tack or layer. The guys in Education Ministries are supposed to be part of the solution; if one examines their role closely one quickly sees that they are part of the problem.

1.3.1 A Case for Canadian Context in Science Education

Having students do their own investigations relevant to their social, physical and biological environment to achieve a realistic frame of reference on the purposes and potential of science are goals which I can heartily support. In reflecting on them though, I am faced with another problem that is not addressed here. Are we really going to allow our teachers the scope to explore problems related to science?

The interdisciplinary nature of science and science as inquiry--Why would these be considered under the heading "Canadian Context". Both appear to be more in an international, discipline-centered context.

1.4.0 Elements of Canadian Context in Science Curriculum and Instruction

In open discussion of the goals and purposes of science education in Canada you must be joking to include once these are agreed upon. Who are you talking about? Do you really expect all stakeholder groups in Canadian society to come to some kind of agreement?

Yes! Any reconceptualization of science education must establish the validity of its rationale in the terms outlined on page 21.

I agree with the objectives advanced fot interdisciplinary study in a Canadian context for science education.

Science education as part of our total Canadian culture and science presented as a way of getting to know ourselves and our universe are not dealing with ideas of the same order.

Noting in the history of Canadian science section that implications of the above indictment are obvious, it would appear that the nice thing about stating that something is obvious is that it saves you from having to think something through. You don't really have to justify the validity of the statement or the purported evidence in support of the statement. However, it makes for better oratory than it does for reasoned argument.

Yes! If students of science education in Canada are to understand the course science has taken in Canada and our present emphasis on natural resources, they must be aware of the tradition in which science is done in Canada.

In the discussion of science policy one must ask if this is really where kids are at? This sounds more fruitful as material for adult education.

1.4.2 Methodological Components of Science Education in a Canadian Context

From where ariseth the great moral conclusion that there should be no room for regional "chauvinism". Let's see . . . First we should have a city wide context to overcome the attitudes of strong local community association context . . . then a provincial context to overcome the city-level association . . . then a national context to overcome the provincial one . . . then a continental context to overcome the national one . . . then a planetary one to overcome the continental . . . then a solar system context . . . then an intergalactic context . . .

1.5.0 Conclusion

. . . The aims and goals related to a Canadian identity in science education have been badly neglected or perhaps "goodly" neglected.

Science Teacher and Science Curriculum Materials Developer (B6)

2.0 General Comments

In my travels across Canada, I've been fortunate to meet a number of science consultants, coordinators and supervisors. In responding to your paper, please allow me to reflect and relate your comments to experience with practicing science educators.

Your concern for a Canadian context in science is valid on two fronts. First, because of the general lack, particularly in elementary grades of science education. Indeed, several of the provincial science supervisors reported an average of one to two science classes per week for levels 1 to 6. This is appalling when one consideres the relevancy of science in our everyday lives.

Secondly, a universal cry for Canadian materials in all subject areas is apparent in my travels. Science seems to be frequently on the back burner in the Canadianization concerns with curricular materials.

Unquestionably Canada's dismal emphasis in pure research when compared with other O.E.C.D. countries must be a relevant factor in accounting for our lack of concern for science education. Historically Canada has lacked a strong commitment to both pure and applied research.

I'm convinced that the integration of physical science with social and natural sciences is critical if we are to realize a significant gain in altering the layman's and student's view of the work of science. Fragmentation, specialization and paternalization to scientific disciplines has segregated efforts and the educational benefits of science education.

I concur with your emphasis on a Canadian perspective in science education, but two reality factors tend to abort any attempts to make progress in this area. Education for Canadians has always been a provincial matter. To bring 10 provinces together with agreement on a Canadian perspective for science education would perhaps be tantamount to getting 10 provinces to agree on a constitution.

Moreover, travels to the provinces reveal very strong regionalism. In the late 60's to mid 70's it seemed to be our goal to develop and promote a Canadian perspective in education. Now this ambition seems to be replaced by a goal for a Saskatchewan, Quebec, New Brunswick and seven other perspectives.

An example can be seen in the work of the Society, Environment and Energy Development Studies Foundation. Even though S.E.E.D.S.

has developed its materials out West and has edited and published our East (truly a Canadian effort), it is still seen by many as an Alberta curriculum project.

I'm convinced that the most detrimental factor in accounting for a lack of interest in science among students is the fact that fun is no longer a part of most science classes. This sounds almost too simplistic but you and I like most "school grads" can recall that some of the best learning environs were also the most fun.

That sense of wonder, the excitement of the unknown has disappeared from science. (I've enclosed a recent article which supports this claim!)

* * * * * *

The article forwarded by the respondent was "When science lost its wonder" by Lewis Thomas, page C10, Edmonton Journal, Sunday, March 14, 1982. The respondent drew special attention to the following three passages in the article.

> First, "We have been accustomed to the belief, from one century to another, that except for one or two mysteries we more or less comprehend everything on earth. Every age, not just the 18th century, regarded itself as the age of reason, and we have never lacked for explanations of the world and its ways. Now we are being brought up short. We do not understand much of anything, from the episode we rather dismissively (and, I think, defensively) chose to call the "big bang," all the way down to the particles in the atoms of a bacterial cell. We have a wilderness of mystery to make our way through in the centuries ahead.
>
> We will need science for this but not science alone. In its own time, science will produce the data and some of the meaning in the data, but never the full meaning. For perceiving real significance when significance is at hand, we will need all sorts of brains outside the fields of science.
>
> It is primarily because of this need that I would press for changes in the way science is taught. Although there is a perennial need to teach the young people who

will be doing the science themselves, this will always be a small minority.

Even more important, we must teach science to those who will be needed for thinking about it, and that means pretty nearly everyone else--most of all, the poets, but also artists, musicians, philosophers, historians and writers. A few of these people, at least, will be able to imagine new levels of meaning which may be lost on the rest of us."

Second, "The education of humanists cannot be regarded as complete, or even adequate, without exposure in some depth to where things stand in the various branches of science, particularly, as I have said, in the areas of our ignorance. Physics professors, most of them, look with revulsion on assignments to teach their subject to poets. Biologists, caught up by the enchantment of their new power, will resist the prospect of broad survey courses; each biology professor will demand that any student in his path master every fine detail within that professor's research program."

The third point noted, "I believe that the worst thing that has happened to science education is that the fun has gone out of it. Very few students recognize science as the high adventure it really is, the wildest of all explorations ever taken by human beings, the chance to glimpse things never seen before, the shrewdest maneuver for discovering how the world works. Instead, baffled early on, they are misled into thinking that bafflement is simply the result of not having learned all the facts. They should be told that everyone else is baffled as well--from the professor in his endowed chair down to the platoons of postdoctoral students in the laboratories all night. Every important scientific advance that has come in looking like an answer has turned, sooner or later--usually sooner--into a question. And the game is just beginning."

Secondary Science Teacher (B7)

2.0 General Comments

A very well written document expressing today's needs of the Canadian science classroom. This is definitely an important issue which must be pursued further to the point of action.

Secondary Science Teacher, Graduate Student and Science Textbook Author (B8)

1.4.2 Methodological Components of Science Education in a Canadian Context

Physics, a Human Endeavour is a re-write of Harvard Project Physics, so isn't really "home-grown."

If students are going to study in the context of their own community it is bound to have a regional flavour.

2.0 General Comments

It seems to me that you have covered Canadian science education quite thoroughly. But, it is not clear to me when you are talking about science and when you are talking about science education.

Secondary Science Teacher and Graduate Student (B9)

1.1.1 Defining the Problem

I felt the introduction to be a bit short. Does a recognition only of international science fit here and some examples of notable Canadian contributors to the field?

Good point on "omission". Would an example of what has been omitted be appropriate.

Amen to using science instruction to become a vehicle for Canadians to add another dimension to their national identity.

1.1.2 A Frame of Reference

I like your point that Canadian context for science education becomes philosophically acceptable within the context of Canadian identity.

2.0 General Comments

I agree with your perspective.

Elementary Science Teacher and Graduate Student (B10)

1.1.2 A Frame of Reference

By sending your theoretical perspective to individuals across Canada it seems you are actually aiming at a concensus of sorts.

1.2.1 The Perceived Canadian Identity Crisis

I find your point about a national abdication being a natural outgrowth of a value system dominated by acquisitive and materialistic considerations to be interesting.

1.2.2 Nationalism and Internationalism in Canadian Science

I strongly support the view of Brouwer that the Canadianization of scientific research and education must not be carried out for "nationalistic" reasons but simply because science and technology can best show their value to all people if they are applied first of all in the local setting in which the research and teaching is carried out.

An important point is noting scientists and layman fail to consider science in a uniquely Canadian context, remaining unappreciative of the cultural role of science, and never thinking about science in an integrative way.

1.3.1 A Case for Canadian Context in Science Education

Having students do their own investigations relevant to their social, physical, and biological environment is a good move.

1.3.2 Definition of a Canadian Context for Science Education

Regarding the content components you suggest should be incorporated into programs to ensure a Canadian context, it is interesting to note that all of these should be included in science curriculum in Canada and elsewhere.

1.4.1 Content Components of Science Education in a Canadian Context

Are you implying that Canadian science is really different from e.g., American science?

It definitely would be beneficial to relate Canadian discoveries to the total discipline as being developed internationally.

As far as I am concerned the "Maximum use of the Local Environment" section is probably the most important thing you're saying. It begins to get at the life-world of the child. Whether science makes sense to him or her and if it relates to everyday life, would be my motivation for coming to the notion of Canadian context. I guess I'm saying that personally I'd push the let's improve their understanding of science and how they can relate to it. I'd use their everyday lives route rather than the let's produce Canucks who are proud to be Canucks route.

In your discussion of foreign science instructional materials it seems like a similar problem encountered in the Caribbean awhile back with a predominance of British textbooks, British examples, etc.

1.5.0 Conclusion

I doubt if we can ever be assured that there will be a majority of scientifically-literate Canadians.

2.0 General Comments

It's a scholarly document, well written, etc. I guess I still question the basic intent behind it, and the push for Canadian context bit: (1) to produce Canadians, strengthen national identity (if so why?); or (2) to improve students' understanding of science, its impact in their lives, etc. If it's (2) I'm 100 percent with you, if (1) I have some pretty serious reservations. Seems to me that if it's (2) the sorts of things that need to be included in any "good" science ed. curriculum should be taught in every country--science-society, philosophy of science, history, etc. The fact that you are teaching it in Canada is essentially no different from the fact that I am teaching it in England. Obviously, however, the examples we use differ, but the principle is the same.

Science Teacher and Graduate Student (B11)

1.1.1 Defining the Problem

By Canadian scientist do you also mean Americans at Canadian universities and in Canadian industry? Is it really important to have a clearly formulated concept of education policy set in the context of a comprehensive framework of general social policy?

Part of being "Canadian" may be the ability to accept happily modes of operation others feel are intolerable.

What are Canadian problems? Do you need to separate basic and applied science or science and technology?

Your perspective might better address the problem to define a Canadian use of science and technology in Canadian education. I'm basically opposed to defining a Canadian context for science education in Canada since I don't know what constitutes Canadian science. How do you differentiate from U.S. science?

1.1.2 A Frame of Reference

Implicit in your attention to the Canadian scientific enterprise is that it is unique.

The crux of your work may be in the assumption that a definition of a Canadian context in science education is both desirable and necessary.

Canadian identity is not a philosophical position. It is perhaps a state of being.

1.2.3 Identity Crisis in Canadian Science Education

Science students were shown to lack awareness of contemporary and historical Canadian society, but what about their teachers?

Is it the teacher's responsibility to Canadianize their science curriculum? Are elementary science teachers also pressured to prepare their students for undergraduate work at the university level?

1.3.2 Definition of a Canadian Context for Science Education

It is unclear which area and at what educational level the content components should be incorporated into programs.

Good luck attempting to get agreement upon the goals and purposes of science education in Canada.

Check out the elementary science curriculum as to whether science education is viewed as part of our total Canadian culture.

Is it true that only Canadians are ignorant of important Canadian achievements in science or does this hold for other countries as well?

Early Canadian achievements such as mapping of resources was done by the British army; identifying and classifying species by English and Scots; and exploring the natural history of the land as a prelude to settlement by French and English. Who then is a Canadian scientist?

1.4.2 Methodological Components of Science Education in a Canadian Context

What is the definition of local?

Is it possible to remove regional "chauvinism" by teaching science in a total Canadian context? What concerns separate regions of Canada?

1.5.0 Conclusion

Is the only way to assure a majority of scientifically-literate Canadians by including a Canadian context for science education?

Science Teacher and Science Department Head (B12)

1.1.1 Defining the Problem

You shouldn't find the statistics regarding lack of recognition of Canadian scientists or achievements surprising since the contribution of Canadian scientists is in highly specific areas and these contributions, for the most part, do not form the basic overstructure in science. In Kuhn's terms, it is only the "revolutionary" scientist that gets notariety and that is a social factor. We have produced for the most part scientists practicing "normal" science.

You might ask yourself if Americans, or Australians, etc. know their scientific heritage any better when it comes to "basic science". It may be quite normal for young countries that have not contributed greatly to "scientific beginnings". Also except for the Harvard Physics Project, and a few others, the human element in the development of science has been ignored by developers and teachers. I suspect a bit of over reaction by some Canadians on this point.

I can only think of a few countries that haven't borrowed liberally from American efforts (in the Western World) particularly England and France. For example, B.S.C.S. materials are used widely around the world. If you read the science education journals, you will note that there is much collaboration with the United States by many countries. This influence finds its way into curricula all over the world. Remember, economics determines the amount of research in an area, and the United States has invested heavily in science education over the past 20 years. Most other countries are newcomers.

Teaching about Canadian science implies expository science teaching, rather than investigative, process oriented learning. If we wish to popularize Canadian science, maybe we need more press coverage as the "Canada arm" is now receiving.

I would agree that the technological aspect of science is not done, or at best not well done in our science in schools. I am personally impressed by some of the work of PROJECT TECHNOLOGY in England (e.g., "Control Technology").

Maybe the state of affairs doesn't deserve any blame from the point of view of Canadian context. There may be blame for other aspects--lack of process education, too much content emphasis; too much authority in science teaching, or lack of social, personal and career needs.

It has not been proven that whatever is done is inadequate. It would be inadequate if it could be shown that its absence has indeed had a detrimental effect.

Science education is for learning about the natural world, not nationalistic chauvinism.

1.1.2 A Frame of Reference

Assuming that a definition of a Canadian context is both desirable and necessary is exactly what I can't accept. I wonder if "Canadianism" is relevant to the education of our youth in any context--except maybe in the study of government. Being a Canadian has meaning only in contrast with other "isms". Truly, from the point of view of science, what does it bloody matter if one's a Canadian or not? Does it really matter if it is a Canadian contribution or a Canadian application? Are our scientists really that hungry for recognition? There will be no more commitment by the student to learn and try to understand science because it happens to be related to something "Canadian", because something Canadian is not necessarily relevant in the context of science.

Yes, Canadian context for science education becomes philosophically acceptable within the context of Canadian identity but to confuse concern with Canadian identity with relevancy of science learning of students is another matter.

1.2.3 Identity Crisis in Canadian Science Education

Snow points out that when art or science becomes subservient to the social order, as in Hitler's Germany, it becomes a vehicle for propaganda as with art or with power and dominance, as with science. Both cultures become vulgarized with the context of the social order. The values of science must be above any particular social order if it is to survive this reduction to social and political whim. There certainly wouldn't be much "revolutionary" science taking place if this were the case. A knowledge of science beyond the social constraints leads to deeper insight in the natural world.

Science has no less relevance than social studies, math, and French for most people. Once any subject or discipline is institutionalized, as it is within the school system, its relevance in the wider social context will be for the most part absent. It is only if we change the total structure of schooling will we be able to get the type of relevance you are delineating. The school as an institution carries with it a contextual influence that only the most inventive and creative strategies and personalities can break down. We must not consider the student, as he is now constituted, to be like a cork on a wave ready to be influenced at the slightest undulation. The student is part of the wave as is the teacher, the school, etc. Bruner's "instructed learning" best typifies the situation.

1.3.1 A Case for Canadian Context in Science Education

Has "basic science" grown out of Canadian history? Can you juxtapose Canadian lore onto "basic science" and justify it? No denying that there are applications to be made within the context of the Canadian social order, but acceleration was given its definition in 16th century "Italy". How do we cope with that? The "Law of Action and Reaction" came out of Newton's era. Might it not be best to let students discover how such ideas evolved out of their original social contexts so that they might better see the "ingredients" for advancement?

A formal level thinker brings whatever thinking is necessary to a problem. If more info about the context is needed, then he recognizes the need. Our priority is to use science as a vehicle for intellectual development.

1.4.1 Content Components of Science Education in a Canadian Context

Was Schwab (1964) referring to anything more than integrating the different sciences? Schwab also points out that each discipline has its own "syntactic" structure as well as "substantive" structure and each must be carefully nourished.

Presenting the interrelationships of science in an interdisciplinary manner is a monumental task from the point of view of attitude change on the part of the teacher. Presently, I am encountering much negative reaction trying to introduce the merits of an integrated program in science alone to get at social and personal needs of students. However, teachers are very discipline oriented.

From what we know from cognitive and developmental psychology, do you really think that students can handle the multitude of variables involved in issues of pressing national concern relating to science and technology?

When a subject such as physics, is considered inhuman, if placed in the hand of a teacher who himself displays this "humanism", the students transfer those feelings to the physics, no matter what the context.

Technology has its own "method" which has to be developed--an example is Geoffry Harrison's Project Technology in England.

2.0 General Comments

I am not convinced that science from a Canadian perspective is the way we ought to go.

In the study of any discipline, say economics, specialized economies are not treated until after the basics are learned. So with science. It is not that I do not see that we should use relevant problems and social issues with the students. But the United States sending up a shuttle craft, or Argentina about to explode an atomic bomb may be more relevant than anything Canadian at the time. I would say make science relevant but not necessarily Canadian.

I think there would be much difficulty teaching basic physics, for example, in a Canadian Context. To imply that the Human Endeavor Series in physics is Canadian to any extent is preposterous. All one has to do is read Harvard Project Physics and there will be no doubt as to the origin. One has a better chance in bringing in the Canadian contribution in the field of Technology. But while I think the technological aspect has its rightful and necessary place in the Canadian School System and even as part of the science curriculum, the "substantive" as well as the "syntactic" structure of technology is different enough from that of science in general that it deserves special attention. Teachers as well as students need to be schooled in the processes of technology as well as in science.

Science Teacher (B13)

1.1.1 Defining the Problem

The role of teacher training should be included with role of instructional materials on page 3. Instructional materials play a very central role but the teacher is the one who implements this material within the context of the classroom, school, community, etc. It is my experience that too many teachers (and therefore, students) are too strictly tied to the printed instructional material. In my opinion, instructional materials provide a convenient excuse to detract from a lack of adequate teacher preparation and retraining. Many teachers feel very insecure when they venture beyond the limited, sterile, theoretical interpretation or context of their discipline. Hence, they are reluctant to do so. I am being intentionally extreme in my position to make the point that the attitude of the teachers is at least as important as the materials themselves. I could provide specific examples of this.

How about a reference to the "ALCHEM" project as an example of what can be done regarding innovative curriculum development and at least a good start at Canadian context.

Why aren't teachers considered as a potential source of curriculum ideas and innovations? Why must major curriculum changes always come from "university oriented" high profile projects? Does your university orientation result in the same biases that you people publish papers for only your perspective?

1.1.2 A Frame of Reference

Acquisition of basic scientific knowledge and process skills is not a Canadian context element, it is a scientific, theoretical context.

1.2.0 The Search for a Canadian Identity

I like the term perspective much better than context.

The difficult task of defining a unique Canadian perspective is not necessarily due to little organized literature on the subject rather there may be no such thing as a unique Canadian perspective.

I disagree with your preoccupation with Canadian identity in relation to science instruction. "You've bitten off more than you can chew."

The most important point regarding science education is a more rounded treatment of science and society (Canadian, where possible and applicable). This involves many perspectives and hopefully will get away from the idea that science is the only way to answer a question.

I really can't see worrying about a "Canadian Identity" and what that means. If we accomplish what I mentioned above it certainly can't hurt or hinder our "Canadian identity" or lack thereof (my assumption).

1.2.2 Nationalism and Internationalism in Canadian Science

The belief that science is universal in nature and should not be restricted by national boundaries and considerations is fine if one is a professional scientist--our students are not and most will not be. As educators we should make more decisions based on pedagogical reasons.

1.3.1 A Case for Canadian Context in Science Education

I would really like to see less talk and more action. Instead of talking about responsibility and what should be done, are you prepared to play your part and provide some Canadian materials for use in the classroom?

Have the universities taken on the responsibility to re-examine the goals in science education established by the various educational systems in Canada.

1.4.2 Methodological Components of Science Education in a Canadian Context

Regarding appropriate professional and economic incentives and support to produce Canadian science instructional materials--have you tried getting some of this?

2.0 General Comments

From my understanding of the word "context" you are stretching the meaning of the word. I find this confusing in this paper. In my view, science education is ultimately the communication of the structure and principles of the discipline. That's the bottom line. How you communicate this and what is selected is a matter of perspective. A perspective is chosen (e.g., theoretical, applied, etc.) and usually an environment to go along with it. Are not the principles of science absolute and independent of the particular environment (Canadian example, use, thinking, etc.)?

The question that nags me is for whom is this document written? Science has run into problems (in the eyes of the public) because scientists have developed language barriers to exclude the layman. It seems to me that "university-based" science educators emulate scientists and have paid and will continue to pay the price in terms of the classroom teachers.

As for your elements of Canadian context for science education, quite a bit of it seems to be common sense to me. I hope that some of what I have written will provide at least some "food for thought" and perhaps a different perspective of a classroom teacher-science educator.

Science Teacher and Science Education Consultant (B14)

1.1.2 A Frame of Reference

Instead of process skills, I would rather see the term inquiry skills.

What is meant by a positive attitude toward science? A critical and even "negative" attitude may do more to improve the quality of scientific work and applications than some uncritical "warm fuzzy", "positive" attitude towards science.

From who's or which perspective is improvement of the physical environment?

1.2.2 Nationalism and Internationalism in Canadian Science

The Canadian character acquired by science may also be due to other dimensions such as aesthetic and religious.

1.4.0 Elements of Canadian Context in Science Curriculum and Instruction

Is it realistically possible to have the goals and purposes of science education in Canada agreed upon.

1.4.1 Content Components of Science Education in a Canadian Context

If a student is presented science including significant historical achievement, a sense of Canadian identity and pride is assumed to be conveyed.

Have the consequences of "issue centered" curricula been carefully examined.

The same point made by Berkheimer and McLeod about complex problems in applied science can be said about focussing on "issues".

Is giving students opportunities to apply inquiry strategies dealing with pressing Canadian problems realistic? They will require more than a scientific/technological solution.

1.4.2 Methodological Components of Science Education in a Canadian Context

What is the difference between teaching science in a Canadian context and regional chauvinism except the size of the region?

2.0 General Comments

It would seem to me that to properly teach science in a "Canadian" context, a prior requirement is thoroughly "Canadian" teachers and authors (i.e., those who are the product of a system envisaged in this paper, those who would present the course context unconsciously because it is so much a part of them, and not in, what I fear will be the case, a sub-conscious and affected manner). Where will these teachers and authors come from?

What is the theory of learning assumed by this paper?

What is assumed or held about this nature and character of the student who will be the subject of "Canadian context" education?

Notwithstanding my somewhat critical comments, I would like to assure you that I have found the paper thought-provoking and well done. Being somewhat unfamiliar with many aspects addressed I was uncertain at times as to meaning. This likely shows up in some of my comments which may be quite off-base in terms both of what is being said and what is intended.

Science Teacher and Elementary Science Consultant (B15)

2.0 General Comments

I do not share your enthusiasm for this topic, which means perhaps that I disagree with the assumption on page 6. I hope, however, that I can offer some constructive criticism. Also, I speak from the perspective of elementary science education which may have less opportunity to be (or not be) nationalistic.

I feel that you have missed the point of the New York Times' article quoted on page 8, that our "nationality consists of an identity crisis with which (we) have a national love affair". The current "identity crisis" typified by your project will continue not until we find the "answer" but until we finally cease asking such meaningless questions.

Our strength should lie in our diversity and in self-confidence. This diversity does not "impinge on Canadians' sense of identity." (page 10) unless we make it an issue.

Much work is being done here in Calgary and, more generally, in Alberta on locally developed units. Many of these are based on "Canadian" materials, but only when these materials are the best available (which they often are). These materials have arisen out of the needs which you list. I agree with the needs, I do not feel there is a crisis.

The regionalism that you decry on page 33 is no different from "Canadianism" when viewed from an international perspective.

Of the six issues listed on page 6, all but the second are pan-national or trans-national, that is, the issue or the need is common to all people in all provinces and all countries. I will go so far as to agree with the need to better display the achievements of Canadian scientists (Fessenden, etc.) along with Canadian achievement in any other field. This, however, is currently happening, often through television or other media. I think we have all heard of J. Tuzo Wilson by now, or Graham Bell, for that matter.

In summary, I feel if we do have a Canadian identity crisis, it is largely because self-proclaimed pundits have convinced us of this. Science education, as a branch of the larger scientific community, should continue to be without flag-waving nationalism. The international scientific community is becoming one of the few unpolluted channels of communication between increasingly nationalistic countries in an increasingly fragmented world. Let's not add to this problem by demanding the Canadianization of a field that, while it may be suffering like everyone else, some underfunding, but is not misdirected philosophically.

Science Teacher and Science Consultant (B16)

2.0 General Comments

You may wish to incorporate some background information relative to government policy that has very definite implications to your study, i.e., bilingualism and biculturalism, which in essence recognized officially only two ethnicities.

You stated and established the relative ignorance of Canadians on Canadian science but have not and maybe should indicate that it is this populace that is making decisions on critical science environment issues. The important factors become political and economic, not scientific that help to make decisions and determine policies.

Some supporting evidence you may wish to pursue is the science training of teachers. Focus not only on the specialist training of teachers of science but also on the training of the generalist teacher particularly at the elementary school level. The Canadian Bureau of Vital Statistics might be of some assistance. Another important factor is the development of a contemporary awareness and attitude of teachers in our classrooms to be able to deal with current science issues and developments in a Canadian context.

C. Reactions of Canadian Scientists, Historians, Philosophers and Significant Others

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Scientists (Physics and Astronomy), Science Educator, and Science Historian (C1)

2.0 General Comments

I agree with the overall thrust of your argument and I think that the kind of education you propose is very important to the future of the country. To achieve the goals you set out, a new kind of textbook is clearly needed, in particular, ones with Canadian content, but also ones that cover the history, nature and social context of science. How can we get them written and sold in Canada?

Another major impediment to the achievement of change is surely the teacher. I do not think that we are attracting individuals to science teaching who have the background (nor perhaps the capacity to utilize the background if it were available to them) to be the combination scientist - renaissance man/woman that is needed. It seems to me that in most studies of education, the most important component of all, the teachers, are assumed to be above being themselves the subject of inquiry.

Your list of the elements of Canadian Content beginning on page 20 is thorough and extensive, but can we really expect to do all that? If we can't perhaps you should make a priority list. Incidentally I have tried to cover a good part of that list in a first year university class for non-science majors. I had hoped that education students would take the class but few did and the class is now dormant.

On page 26 you imply that applied science and technology are the same. I disagree. I would suggest that technology is often the result of applied science.

On page 28, I would prefer to interchange "process" and "content".

My next point has been addressed to some extent by your latter pages but I think it is still worth raising here. I have had much discussion of this point with Jim Page and Tom Symons. I support use of the Canadian context wherever possible but there is a good body of science content where it would be at best gratuitous. The principles of the inclined plane, oxidation or genetics cannot be easily Canadianized. I always talk about bathtubs and the Bay of Fundy when talking about resonance, but there are limits to the availability of uniquely Canadian examples.

My final point flows from the previous. Much of what we both advocate is not science teaching but rather the teaching of the history, sociology, economics, etc., of science. The "Canadian context" is much more relevant to these subjects and I support your advocacy of its use. However, perhaps we should not let these new subjects replace the small amount of science itself that is now seen by children in schools.

Canadian Geographer, Social Science and Canadian Science & Technology Historian (C2)

2.0 General Comments

This first chapter is an impressive review of literature and approaches to the problem. I am impressed with your command of this broad field and have nothing to add. When I have the time, I shall attempt to follow up some of the interesting references cited in the study.

Urban historians and geographers would probably take issue over your statement on page 10--"Canada's toleration for foreign control and influence over its economy and culture, so strikingly visible in the physiognomy of Canadian cities and towns . . ." While many of the forces are very similar, the detailed appearance of Canadian urban centres is markedly different from neighbouring American cities--obvious differences show in the greater strength of central business districts, the real absence of "ghettoes," strength and reliability of municipal government. This is a minor point in your discussion but it might be worth modification.

Canadian Science Historian and Science Educator (C3)

2.0 General Comments

This is all enlightening and hopeful, but here is the reality as I've perceived it (from contacts with education and in teaching--especially in teaching science to primary and secondary school teachers):

(1) Teachers (especially primary level) know very little about Canada, period.

(2) Most of them know even less about science and they don't want to know any more. They perceive it as too difficult.

(3) No matter what provincial curricular guidelines are introduced, nor what materials are produced, if teachers fear or misunderstand science, they will neglect it in the classroom. My oldest son has been a victim of this for five years in our "progressive" Ontario system.

So, before we do anything about "Canadianizing" science education, we have to put tremendous effort into science education on the most fundamental level.

Canadian Science Historian and Education Officer for Museum (C4)

2.0 General Comments

Fully support the theoretical perspective as put forward, however, it would first be necessary to educate the teachers in ways to include the elements of a Canadian context for science education.

Canadian Anthropologist and Educator (C5)

2.0 General Comments

You must define clue structure early and right in the body of the text.

There are two major questions which come to mind. First, what do you mean by science? Do you mean mathematics and physics or agriculture, hydrology, oceanography? Second, what is meant by Canadian?

Can we discuss Canadian mathematics by substituting arctic char and grayling for apples and oranges in problem solving? You can't take the word science for granted.

Does Canadian context mean Canadian views? You are dealing with a dimension of Canadian mentality--it can't be done.

As for "Problems of Regionalism", as has been shown by Laurie Raccou from U.B.C. the idea of regional identity is a growing trend. The idea of nation state is diminishing as is reflected in poetry and novels.

The question is one of realism. Is is realistic to think one can get the package you describe? Would it not be feasible instead to start by preparing and encouraging teachers to make use of the local environment?

Canadian Cartographer and Science Educator (C6)

2.0 General Comments

The notion of clue structure should be clarified.

The general direction of the paper is good. There is a serious problem though. It is somewhat naive to think that science teachers, who are already complaining about a overloaded curriculum are going to start taking the time to add a Canadian context to the knowledge already being disseminated. Anything that is going to add to the existing body of knowledge at each grade level will be met with resistance on the part of the teacher.

Canadian Geographer, Historian, and Science Educator (C7)

1.1.1 Defining the Problem

A number of universities have fallen down badly in the area of attention to Canadian dimensions and problems in science teaching and research. We can look to a number of U.S. programs in Canadian studies which could serve as useful models.

What is science? You need a broad definition of science. How do you put a Canadian stamp on science education?

Define clue structure earlier.

1.2.2 Nationalism and Internationalism in Canadian Science

You must consider that the belief that science universal is widespread as you indicate. This makes the term "Canadian science" immediately controversial.

1.2.3 Identity Crisis in Canadian Science Education

One of the reasons few recommendations on Canadian context were followed is that there is much more emphasis placed on the importance of the role of science rather than the role of Canadian science.

1.3.2 Definition of a Canadian Context for Science Education

Is there a regional science component included in a Canadian context?

1.4.2 Methodological Components of Science Education in a Canadian Context

Foreign materials will continue to be used extensively primarily because of the economics of publishing. This is a crucial factor.

Canadian Historian of Medicine and Science, Science History Educator (C8)

2.0 General Comments

The issue is a broad one, and you seem to have covered the existing literature very well.

Science Materials Publishing Consultant, Doctoral Student (C9)

1.1.1 Defining the Problem

A performance-objective oriented teacher/professor might take exception to the terms "development of an understanding and appreciation of nature".

1.2.1 The Perceived Canadian Identity Crisis

Eastern feelings also run more to the south than to the west. Very closely tied to the flow of commerce, for both halves of the country.

Peter Newman, in a Maclean's editorial a couple of years ago, spoke of the United States/Canada difference as that of a country based on "peace, order, and good government", instead of on those nebulous qualities, "life, liberty and the pursuit of happiness". Maybe we just "don't want to cause any trouble".

1.3.1 A Case for Canadian Context in Science Education

You haven't talked much about stated goals, only about practice. An examination may show that the goals are very much as you describe on page 6 and that the real problem is implementation, as suggested by Page (page 17).

I'd almost like to see the benefits listed on page 18 (the last paragraph) in "flashing lights".

1.4.1 Content Components of Science Education in a Canadian Context

The study of a discipline in an appropriate context does not require the abolition of separate disciplines. Don't threaten people's turfs if you don't have to. Cooperation and communications are essential, of course.

Governments dictate the kind of pure and applied research being done because they have the money.

1.4.2 Methodological Components of Science Education in a Canadian Context

Economies of scale of production may be derived for the U.S. publisher by selling instructional materials on an international market but Canadian publishers don't get their books accepted elsewhere.

2.0 General Comments

First, let me say that I like your style; it's a comfortable, easy-to-read way of writing. It's very reassuring to discover that some people still know how to use the language!

You acknowledge the extent of the Canadian-context problem in Section 1.1; that's good. I'm sure that you've seen newspaper polls showing that knowledge of Canadian history, politics, and literature is equally abysmal.

We tried to do something about the problem in the first edition of mathways (Copp Clark, 1975) by setting the math in Canadian contexts: government, wildlife, native peoples, etc. In the Level 3 text, we wrote special problem solving lessons to deal with specific Canadian topics: the Montreal metro, a Newfoundland fishing village, the westward push of the CPR, etc. Much to my chagrin, a lot of that was deleted from the second edition. Hardly progress!

One reason for more emphasis on Canadian contributions to science and technology is that it is in those areas that many future jobs will be available. We're going to be keeping ahead in such areas as special oil riggings (off-shore, ice-field, etc.), cable TV systems, and cardio-vascular research. One of the school's tasks is to make preparatory education in those areas available to students. (As I watch the Columbia III mission reports on TV this week, I am absolutely delighted that the robot arm - designed, built, and pretested in Canada - is working flawlessly.)

I'm a little concerned that the search for a "Canadian identity" still goes on (Part 2 of your paper). This was a topic in Social Science 102 at York University in 1965/66! (See our text, entitled The Canadian Identity.) With the world becoming relatively smaller each day--on the time dimension--I, personally, feel the need to focus on Canadian contributions to the world at large. Look outward, not inward. Perhaps I'm one of the internationalists you condemn so roundly on page 15.

This is a time-worn excuse, but the basic reason so few Canadian texts are published (I'm looking now at page 17) is that the development and production costs are as great in Canada as in the US, with roughly one-tenth of the market size to support them. It is much more feasible to buy US film and "Canadianize" the material. (I made a pretty good living doing that, myself!) I might add, as a former marketing person, that school boards' and provinces' willingness to purchase US texts--even when Canadian texts are available--doesn't help.

I believe that some new Canadian secondary school science texts were published during the past five years by Prentice-Hall, Heath, and others. "Ask your local rep."

Science and Technology Editor (Major Canadian Text & Book Publisher) (C10)

1.1.1 Defining the Problem

In what ways was improving the amount and quality of Canadian context in our science curricula to have a favorable impact on present and future students?

I find the lack of attention to Canadian dimensions and problems in research to be extraordinary. What about all the NRC's work in the building science area--another environmental perspective almost entirely.

If science instruction is to become a vehicle for Canadians to add another dimension to their national identity, it is not only by identifying a Canadian context for science education and by identifying Canadian ideas that we should be communicating to our students through science instructional materials but also by making sure that teachers teach it.

1.2.1 The Perceived Canadian Identity Crisis

Isn't the main reason science education has not been rooted adequately in a Canadian context really that the market is limited and it is only with (1) a core curriculum throughout or (2) a freedom of choice of texts so long as those texts are Canadian this will occur.

Ontario's policy is that the educational market is "sure" enough to encourage publishers to product indigenous texts. Only (2) is a reality.

I think the "identity crisis" has been less a problem than lack of policies that encourage Canadian content. Of course, one resulted from the other. What you're talking about then is history. The 1960's presented teachers with U.S. programs, PSSC, BSCS, Chem Study. But the 1970's and 1980's presented Canadian authored and printed texts to the marketplace. Naturally these materials conformed to the Ontario curriculum because that province allowed for Canadian choice of texts only--a real boom to Canadian publishing.

I don't believe the assumption that Canadian academic interests, priorities and values are considered inferior, since throughout the world Dalhousie and U.B.C. are known as excellent marine biology centres; Waterloo is considered the top in hydrology and computer science; University of Alberta has one of the top civil engineers in the world, as does the U. of Toronto; and NRC scientists work is respected everywhere.

Surely every land has unique features.

1.2.3 Identity Crisis in Canadian Science Education

Things are changing so dramatically in the schools that Symon's 1975 views are history.

It is true that very few Canadian texts are suggested as readings and that few recommendations on Canadian context were followed in the Ministry but new revisions in Alberta and British Columbia are leaning that direction. The danger is "provincialism" with the possible loss of Canadianization.

2.0 General Comments

This is a topic in which I am quite interested and which I feel has previously been extremely important. However, I think that you must consider that much of what you say is now history. The initiation, in the previous decade, of the policy by the province of Ontario to approve for their elementary and secondary courses only those books that are Canadian authored, published, and printed, served as a tremendous stimulus to publishers here. Thus, most of the problems that you are indicating have recently been alleviated. A look at any of the new science books authors have produced for John Wiley & Sons Canada Limited, I am happy to say, will show you that. Prentice-Hall, McGraw Hill-Ryerson and Heath are other companies that are responding to the need for Canadian science materials. In addition to making our books more relevant in terms of Canadian content, one of the main thrusts of our science program at Wiley is to make certain that the lack of practical perspective that was manifest in those 1960 post-Sputnik years, is no longer lacking. We hope that we have developed the "right" mix of theory and practical content in order to make our books both exciting and relevant to the student, and to give the needed theory base for thorough understanding of the topic. Mentioning the books we are producing is done here only to indicate that the points you are making are the points that have been recognized by publishers. At present, several other provinces have also become extremely concerned about Canadian content and are urging their teachers to use Canadian produced books. One concern here, and one that you might be interested in researching is that many other provinces have felt that the books produced in Canada have been too eastern oriented. Thus, there is an emphasis on more regional publishing, a fact that has both its positive and negative points, as you might imagine.

I am not certain what you mean when you indicate that this theoretical perspective is the basis of a clue structure which you will be devising as part of your thesis. It seems quite repetitive in its proposition that there should be more Canadian content, and it appears to me that the most important way to determine if instructional material has Canadian content, and type and extent of it should be determined by a series of questions about each material, such as those listed on page 22-24.

Senior Science Archival Officer National Research Council of Canada (C11)

1.4.1 Content Components of Science Education in a Canadian Context

Will the "average person on the street" ever be interested in anything but the practical results of science?

Did provinces become significantly involved in pure research?

Does development support pure science?

2.0 General Comments

In general your analysis of the problem and your proposals for dealing with it seem to me to be sound and well worth developing. The least soundly based section and probably one of the most difficult, is 4.1.7 which deals with Canadian Science Policy. It is tempting to accept the views of Glassco and Lamontagne that no science policy machinery existed in Canada before the 1960's. However current, but so far unpublished, historical work is beginning to show that there were in fact mechanisms operating during the 1940's and 1950's which worked well but were overlooked by both groups. While both Glassco and Lamontagne deserve to be listed as milestones in the evolving discussion of science policy, I doubt that informed observers a few years from now will regard either of them as having had a good understanding of how science and technology really work. And while your list of "determinants of Canadian science policy" in (ii) is a not unreasonable one, there are strong arrangements for discussing science policy in terms of more down-to-earth goals such as those suggested by Bachynski (quality of Life, Economic Development of Canada and Employment).

I would like also to express my feeling that one of the more effective ways to apply the principles you are developing would be to place more emphasis on applying them at early (i.e., elementary and junior high school) levels. All too often discussions of science teaching tends to crystallize into the planning of courses at the post-secondary level. If we are trying to develop in Canadians a recognition that science and technology are integral parts of our society's culture, it might be easier to do this before students get too far down the rigidly disciplinary paths into which our educational systems seem to channel them. I note that Symons, in discussing the need for a better knowledge of our country's history refers to "Canadian school children".

Canadian Science Historian and Philosopher, Science Educator (C12)

1.1.1 Defining the Problem

Not only does the lack of coherent Canadian context pervade all education in Canada but so does lack of context--the literacy or familiarity with the structure of my discipline and its achievements.

The failure of Canadians to recognize that science and technology are integral parts of our society's culture is much more serious than the lack of attention to Canadian dimensions and problems.

1.2.2 Nationalism and Internationalism in Canadian Science

The fact it would be hard to find any country whose scientific structures and attitudes towards science are more clearly rooted in geography and history is an argument for teaching the history of science as part of the history and geography curricula, and urging science students to learn science history and some geography.

1.3.1 A Case for Canadian Context in Science Education

Agreed! A holistic view of the nature of science and its relation to Canadian society should be a goal for all citizens, not just scientific!

1.4.1 Content Components of Science Education in a Canadian Context

I would suspect the reason interdisciplinary education has failed in Canada is that to be effective, good interdisciplinary work requires prior competence in the separate disciplines.

2.0 General Comments

There are many good things in this proposal--Education about science as a part of society is something that should be part of every student's program. It is important to maintain--or perhaps to develop!--excellence in the intellectual comprehension of science that should be the goal for all would-be scientists. These are not mutually exclusive. I'm glad that you have sought a balance between national and international aspects--ignorance about Canadian science is marked by ignorance about science tout court, and we gain nothing from parochialism. And, of course, I'm glad that you assert the importance of the history of science--I urge you to consider this for students of history at least as much as for students of science.

International Specialist in Curriculum Theory and Development, Education and Author (C13)

1.1.1 Defining the Problem

There are a couple of real minor points and then I want to raise a couple of other kinds of issues. I was unclear. Sometimes you almost make asides and then it is not clear what you are claiming. On page 2, you say "reforms in education are almost pragmatic". I really don't understand what you mean by that. The thing that puzzled me was the sense of "almost", "also". I don't quite know what that means. I got the sense that of your claim was to pull stuff out of its context, you take it from the States and throw it in here with little change and assume it will be sufficient in Canada. I agree with your claims about that and think that is a really important point. I just wasn't clear what the words stood for.

1.1.2 A Frame of Reference

Another very minor point: you don't define a clue structure until after you have used it many times.

1.2.1 The Perceived Canadian Identity Crisis

On page 10, you say "Analysts both inside and outside Canada observe that no country has been so willing to be exploited, or to have so supinely encouraged the take-over of its resources or mind as has Canada. This national abdication is a natural outgrowth of a value system dominated by acquisitive and materialistic considerations."

I'm not certain what the nature of your argument is there. That is, one of your points is something like this: to the extent that we are materialists; that extent we want to advocate to save Canada or elsewhere from foreign control. On a general level I understand what you are saying. I think that is also wrong. Let me give you an example. Saudi Arabia is being transformed into a capitalist nation. At the same time it's value structure is changing towards a much more materialist base. Let me take Nigeria as another example. It is becoming much more individualistic yet at the same time they are incredibly strong in resisting foreign domination and, in fact, work very hard sometimes against the oil cartels in attempting to establish a cartel that they control. So there is no natural outflow. There is no logic that says as soon as you are a materialist in Canada or any other country that you must have a foreign domination. In fact, you could have exactly the opposite effect. You could become more materialist and say that in order to get more individual goods and services we have to control it ourselves. So it is a puzzling claim. It doesn't bear on your argument a lot but it is a claim that I think is wrong.

On page 11, you say "It has often been easier to borrow or buy other people's ideas, technologies, aesthetic works than to develop and encourage our own, but one wonders at what price to future Canadian development". One might want to speculate that this has something to do with the recency of development of resources so that the attitudes are basically developed under a specific stage of capitalism. That is an inquisitive stage where you have a growth of hedonistic individualism in some ways, with the state intervening to guarantee that corporations get a good profit. Now that occurs, in part, with one explanation: that given a recency of 50 to 60 years of development, naturally less here, natural development here both of specific industrial mining, large scale mining and large scale government oil resources comes at a specific stage of the economy. So you might want to begin to speculate about why it has been easy to borrow and buy other people's ideas, etc. in technology. That has to do in part with, not necessarily this vague thing called an identity in Canada, but the relationship between the people here and what specific times something has been developed. Because if you look, say, in Texas or in Pennsilvania, large oil producing states in the United States early on, you find a different norm--a much more cooperative kind of thing. This is developed at a stage where it is less dominated by large conglomerates (large cartels in the market) and there had to be a reliance on self. So again you want to look internally then at economic forms and why those types of things might occur. Obviously identity isn't divorced; at least one's sense of what raw materials are available, and what you should do with them is going to be determined by the market. So what I'm saying is just speculating.

1.2.2 Nationalism and Internationalism in Canadian Science

A minor point where I think you misuse Polanyi a little bit. You are not talking about science as not just laws. It really does have a national or cultural dimension and this is part of a claim where you are saying it is really important that people see the relationship between science and specifically Canadian society. Now you say Polanyi supports this view that science is very much a part of the culture of the country. I'm not certain if that is really what Polanyi is claiming.

Most of the time when Polanyi talks about the culture of science it is to answer the question who is "man" and his argument is that it is specific to the human condition. So in the identity of man, for instance, he argues that science and poetry are linguistic experiments that show the possibility of cultural forms. That is that both are creative; both are poetic acts; both are forms of experiment. The logic of science says the experiments make a decision. The logic of poetry, and drama and literature and arts is to dwell on a particular situation so you understand yourself and others better. So it is a set of cultural meanings in the sense that it is created by a community and it is part of the many constructions of that community. It is not countrified. In some ways it is not part of the culture of the country, it is part of the culture of the community. So you might want to be careful about that. The best place to look to see what Polanyi means by that is his volume called The Identity of Man. He goes through an especially nice argument against behavioral objectives, and goes through whether the mind can ever be treated like the computer where you can know everything that goes in and comes out. And then he says the reason is because science isn't like the computer. There can be no certainty. But why? Because it is always a form of linguistic experimentation. It is as much a play in art as it is certainty. How does that differentiate from art? He makes a lovely analysis between the strong relationships between good science and good studies; which is just delightful and which is what good scientists have been yelling for years.

1.2.3 Identity Crisis in Canadian Science Education

On page 15, in the last paragraph you say "this neglect of Canadian context in education is partly motivated by an attitude, exhibited by some Canadians, that they could not care less about Canada, being internationalist to the core. The attitude that our country has nothing unique to offer and why bother with Canada when considering science when the problems of the world are so pressing can have a very detrimental effect on science education in Canada."

There is a logical issue there I want to raise. It is the case that this notion "why should we bother about Canada when we consider science in light of the problems of the world that are so pressing" is bad. What we could have, and you might not agree with the kind of science that is taught, but you could have students in Canada deeply involved in science: industrial science, applied science, it could be pure science and not give a damn about Canada but you could still have a lot of science education going on. But you want to stipulate that science education is only science education in its best sense, if it goes beyond the internal dynamics of science. That is it's not science ecucation because science isn't this pristine thing. Science is always related to society in some ways. It is part of the culture of meanings and community that is very important and it also has a strong situation in the existing society. So one way of strengthening your claim there is to say now--almost to summarize at this point--say okay why will it have a detrimental effect because I've already been at pains to show that good science doesn't look like this internal thing.

On page 16, is where I think that it's really not your problem, though you are going to have to try to deal with it because it is specific to the general literature.

Occasionally you switch issues. This is really confusing, not in here, but it is real confusing in the literature. There is a general problem: What is the relationship between science and society? So you get things like Nolton and Gill and these folks arguing very strongly that the relationship of science and society is science grows at the same time as the protestant ethic. Hence, we can see that good science has a strong relationship to puritanism and he does a brilliant analysis of this. Now, that's a different relationship. That is the general issue of science and society are linked by particular norms that evolve, that work off each other, and so you want to raise that but at the same time you want to say--but we have to see science and its relationship to the growth of Canada, the possibility of it, and how it has contributed in some ways. That's a different problem but it is still under this general rubric of the relationship between science and society. There is this gap between the two that isn't really clarified and it's not clarified in the general literature either. People jump from this general issue of science and society, the norms of science and the norms of society to this thing that you are very concerned with as well. How do we show how science has contributed to

Canada? How do we get this consciousness of the past into the heads of these kids so that they realize that Canada's contributions to science are major? Again, that's a different problem in some ways than the general issue of wanting them to study the relationship between science and society. An example would be the relationship between the growth of particular conceptions of physics, say relativity theory and similar kinds of concerns that were being generated in philosophy. Liptinstein's notion of language gains where the way you see the world is relative to the growth of the petty bourgeoisie; this notion of demystifying particular values that everyone is supposed to share relative to science. The attempt to show the parallel development of these and to speculate about what's the relationship then between intellectual work and science, which is supposed to have no relationship whatsoever to society, is pure and these similar kinds of forms are growing up in every arena. Again that is different than the problem you want to focus on. So there is a logical gap, not just here, but in the literature itself in trying to take those issues and then apply it immediately to how we figure out the place of science in Canadian society. Those connections aren't made yet. But they're not made by anyone so you might want to think through whether there is a literature you can draw upon or try to clarify for that.

1.4.1 Content Components of Science Education in a Canadian Context

On page 26, you say that "Canada was unique in that the advance of science followed technology which defined social needs rather than preceded it" and in part I get the sense that you are saying this is good and that it's important that we show this to students so they get a sense of importance of science in their day-to-day lives.

One thing that sometimes is unclear is that you stipulated a lot of definitions of science (ones that I agree with so there is no problem) but sometimes it's unclear what your position would be. That is, one could read this and say really what you want is for kids to get a fond view, a positive view, of what Canada did. That is, instead of starting off with science in its abstract sense, it starts out with a vision of science as technology where one borrows from a lot of places and you develop your resources. Now in other places, you seem to say "wait" that's not very good. But in your curricular proposals here, in some ways this is the sense that says what we really ought to do is teach that as Canada is unique; it was a very, very good thing to do that but you've already made some claims that in a way that led to the despoilation of the environment and stuff like that. So the critical cutting edge of that is missing right now. It's not clear again where you would stand on this issue. Now, it may be that this is a political document in a different way because you have to write very, very neutrally. I understand that but again there is a confusion in it sometimes that is unclear. Do we want kids to see this positively? Here is what Canada did. It started with technology and built science from technical problems and in that sense borrowed. So science and industry became almost the same. On the other hand you do want to claim that--wait a second, we have to be very careful about environmental issues, about the despoilation of our resources, the foreign personnel, etc. and there is a confusion in that because one time you say that strategy is unique and good but you also claim that strategy is what has gotten you the problem in the first place. So you might want to think more about that. There is a book by David Noble called America by Design and he shows the industrialization of pure science in the United States. It's a funny book, it's brilliant--just real good. He looks at the growth of engineering and tries to show how pure science was taken over by engineering in the States and you have the industrialization of science. So any real problems that are considered worth funding are then technical problems and it traces out a similar thing that you are pointing to in Canada but on a larger scale. He's very, very negative about it so it might give you a perspective that gives some power to the kinds of things you want to say.

2.0 General Comments

You write very, very clearly so I think that is a real strength. It is a pleasure to read.

I think that you are trying to do something that is critically important and because of that it raises analytical difficulties that are not just in this, but are more general. That is, in order to solve the problems, there are problems that are naturally generated by the relationships in science and society and you may get caught on the horns of the dilemma. Sometimes, it is hard to solve general problems at the same time as you are trying to apply it to a Canadian context. So there may be problems in here conceptually that are not solvable by you but specific to the literature. Some of the comments that I have raised may be nothing that you can do anything with and, of course, it's in the literature itself.

Again, it was written very, very clearly and it flowed. I was very pleased with that. I thought you were very careful to not overstep the bounds within the context of trying to reorient science education and not to overstep the bounds so much that people couldn't follow you or when you came close to trying to do too much you back off and say wait a second, here is how it fits into the issue of Canadian identity and I thought that was well written. I was pleased with it.

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APPENDIX V

STAGE V: Validation of the Clue Structure by Science Teachers

Included in this Appendix are:

(1) A covering letter from the researcher to selected practising science teachers in Edmonton Public Schools, the Edmonton Catholic School District and the St. Albert Protestant Separate School District.

(2) A copy of the questionnaire used in Stage V.

(3) A composite of the written comments made by survey participants in the open section of the questionnaire.

(4) Copies of letters granting permission to carry out the research component of Stage V and a copy of the Cooperative Activities Program Form.

The fourth item has been included to verify that the research carried out in Stage V of this study, under the Cooperative Activities Program at the University of Alberta was done with the approval of the attending school district offices.

COPIE DE QUALITEE INFERIEURE

Dear Colleague,

Your student teacher has taken part in a study to determine conceptions of a Canadian context for science education held by prospective science teachers and practicing science teachers. In order to analyze the viewpoints endorsed by practicing teachers at different levels of secondary education instruction and in different science disciplines, an attempt is being made to seek the perspectives of the cooperating teachers associated with those student teachers who have participated in the study.

The instrument used is a questionnaire which asks the participant to rate their agree/disagreement for inclusion of various elements in a Canadian context for Science Education. The sample will be analyzed for relationships between viewpoints of the following groups.

Biology Phase III Student Teachers
- Jr. High Cooperating Teacher
- Sr. High Cooperating Teacher

Physical Science Phase III Student Teachers
- Jr. High Cooperating Teacher
- Sr. High Cooperating Teacher

Your participation is greatly appreciated. All information regarding the identity of participants will be held in strictest confidence.

Please have your student teacher return this questionnaire at their next call-back session. Thank you.

Gratefully yours,

Rick Mrazek
Instructor, Secondary Education

RM/cl

COPIE DE QUALITEE INFERIEURE

Conception of a Canadian Context for Science Education

Science education includes a number of contexts in which science may be presented. One of the many possible is a Canadian context. If one assumes an encompassing definition of Canadian context then included would be all prevailing knowledge, beliefs, values, morals, customs, laws and other attributes which are specifically associated with individuals who inhabit the boundaries of Canada. This would also include influences on these cultural components such as history, tradition, population mix, geography, science and technology, and the political and economic system.

This survey requests you, the science teacher, to indicate the elements you feel should be included, when possible, in teaching science education in a Canadian context. Using a pen or pencil, blacken one response circle for each item.

Please respond to all items.

SA = strongly agree   N = neither agree nor disagree   SD = strongly disagree
A = agree   D = disagree

In order for Canadian students to obtain the best possible view of the nature of science and its relation to Canadian society, the following should be included in a Canadian context for science education:

1. An interdisciplinary approach to science facilitating study of man's interrelatedness with his natural and social environment.

   (SA)   (A)   (N)   (D)   (SD)

2. Promotion of an understanding and appreciation of the relationship between science and Canadian society including the impact that science and technology have on Canadian society and culture today.

   (SA)   (A)   (N)   (D)   (SD)

3. A depiction of how science and technology can be used to alter the economic and political situation in Canada.

   (SA)   (A)   (N)   (D)   (SD)

4. History of Canadian science which includes the impact that science and technology had historically upon Canadian life.

(SA) (A) (N) (D) (SD)

5. Promotion of an awareness of the role of Canadian scientists and technologists in Canada's growth and development.

(SA) (A) (N) (D) (SD)

6. Recognition of contributions made by Canadian scientists to international science.

(SA) (A) (N) (D) (SD)

7. A knowledge of the tradition in which science is done in Canada including present emphasis and philosophy underlying Canadian science.

(SA) (A) (N) (D) (SD)

8. Acknowledgement of the interrelationship of pure and applied science allowing a description of the world as it is while also showing the means by which the environment is adapted to suit man's needs.

(SA) (A) (N) (D) (SD)

9. Attention to methods of inquiry which can be used in dealing with pressing Canadian problems which require a scientific/technological solution.

(SA) (A) (N) (D) (SD)

10. A treatment of Canadian science policy promoting an understanding and awareness of the differential emphasis on certain areas of research in pure and applied science in Canada.

(SA) (A) (N) (D) (SD)

11. Maximum use of the local environment through experiences and examples using the immediate natural and social world in which the student lives.

(SA) (A) (N) (D) (SD)

12. Inclusion of topics and problems of current local scientific significance which could include taking feasible action on suggested solutions.

SA A N D SD

13. Inclusion of Canadian produced science instructional materials which students may easily relate to their own life and environment.

SA A N D SD

14. Provision for teacher's guides to show how foreign instructional materials can be used or supplemented to be considered more in line with Canadian educational circumstances and needs.

SA A N D SD

15. A method for bringing the unique problems of each of the major regional areas in Canada together into one context interrelated through common concerns.

SA A N D SD

Opinion: Most of the important considerations for inclusion in a Canadian context for science education have been mentioned.

SA A N D SD

Please identify other considerations which you feel should be included in a Canadian context for science education. Some of these are:

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Written Comments Made By Survey Participants

1.0 Student Teachers

1.1 Biology

- The data of this paper could easily be used for manipulation of anybody's point of view.

- Canadian content in science should not limit itself to a study of Canada only. At present Canadian texts are not adequate for the level of attainment which the board of education seeks.

- Should science be considered in terms of nationalities? Specific areas or topics of national interest might be included presently in science courses. Applications, technological implications, societal interactions with science might be usefully treated in a specific national context - but "science"???

- It seems unfortunate that so little Canadian content is available. I hope this won't produce a curriculum full of useless Canadian content into the existing curriculum.

- If a Canadian context is being developed, a purposefully global context should also be developed. A Canadian context encourages nationalism and the idea that Canadian concerns are more important than other nation's problems. I feel that rather than letting American materials dominate over school systems, a global worldview context should be developed.

1.2 Physical/General Science

- There are regrets for the science program understood was that science is never country orientated but universal.

- Suggestion - inclusion of Canadian teachers who have a good English background (speaking, writing).

- Canadian texts especially Canadian inventors, scientists should be included

1.3 Elementary

- Point no. 8 should also include effects of such adaptations.

- Point No. 11 is alright.

- Point #13 only if the materials are significantly different and helpful to Canadians

- Can't think of others (more considerations) topic well covered.

- Like the idea of having kids learn about problems and how to solve them and actually taking part in the solution.

1.4 Environmental

- People within the scientific community who could be contacted with regard to specific areas of interest to individual students should be included. A listing of this type would be very helpful for teachers in the sciences.

- Science should stress the interrelatedness of the actions and technological advances of man and their effect on the environment. It should stress the environmental changes. May come back to affect man.

- The importance of technology ie. the impact on citizen lives - negative and positive issue of progress - isn't necessary or not (maybe more in economic line).

- Some scientists not living in Canada who developed or discovered something big were originally Canadians ie. recognition of Canadian scientists not only in Canada but elsewhere.

- Guidelines for related Canadian Wildlife problems should be included.

- A program related to resources Canada should be included.

2.0 Practicing Teachers

2.1 Biology

2.1.1 Junior High School

- There is a problem with defining the distinction between pure Canadian science and other types of pure science (question 8).

- Most strongly agree that meaningful relevant science is that science which can be related to students own experiences in-the-world. This is adequately covered in questions 13, 12, and 11.

2.1.2 Senior High School

- Time frame for teaching science is very limited - thus to include or expand on Canadian scientific studies, methods and discoveries would be difficult.

- Only so such a student teacher can do in a 3 credit or 5 credit course.

- The inclusion of Canadian content etc. should be the responsibility of the educator rather than the actual textbook or materials.

- With respect to Biology - it is important to include regional information - eg. population studies

- Rather study the 'florida cotton mouse' perhaps specific statistics could be obtained on the 'deer mouse'.

- Utilize the Canadian Wildlife service.

- Questionnaire covered the topic thoroughly.

2.2 Physical/General Science

2.2.1 Junior High School

- 99% of audio visual materials for Grade 8 Science in U.S. produced. The topics of the course such as geology and meteorology could and should be Canadian. So often when students realize a film is talking about the U.S. they just turn off - it is not of any concern to them.

- Most of the major considerations have been covered adequately in this questionnaire.

2.2.2 Senior High School

- Is there a Canadian science?

- Nature of science (or Canadian context) needs a provision for students to devise lab procedures

- "case studies" eg. acid-base theory, periodic table, etc.

- Less mathematics and more emphasis on the "essense" of science and what it is.

- Canadian context could be one context but many others are important eg. economic, political, pedagogical, environmental, societal, consumer, applied, etc.

- Don't think one should limit any course to a "Canadian" context but should include Canadian references wherever practical.

- Survey is similar to asking about motherhood. Once you agree that science teaching should have a societal context then you can't really disagree with any of the points put forward.

- Different societal emphasis would be highlighted in different areas of a science curriculum. The key question is what will be the contextual setting in a given topic. This need not interfere with "real science" concepts.

- The 15 questions posed cover all considerations adequately.

- The questions seem to lead the participant rather than give him/her a choice. The wording of some questions want the participant to agree with the composer.

- There are seven major categories that one can relate or integrate into the Canadian Science content.

  1) History
  2) Canadian Industrial and Technological Revolution
  3) Economic Implications (Canada and internationally)
  4) Social Implications
  5) Religious Implications
  6) Legal Implications
  7) Political Implications
  8) Moral Obligations

- Science curriculum (Chemistry, Biology, Physics) is jammed with introductory science information and basic concepts.

- It would be impossible to cover all these Canadian aspects.

- Best left for other classes such as sociology, economics, law, religion, history to be covered more thoroughly - especially in the organic unit.

- Relate this to "ALCHEM" - many local examples used, except they are just mentioned in passing.

- It is impossible for us in the field to integrate them in any detail to be worthwhile to the students.

- Could be used in ecology, genetic engineering or student projects.

EDMONTON PUBLIC SCHOOLS

March 22, 1982

Mr. W.A. Kiffiak
School Liaison Officer
Division of Field Services
The University of Alberta
Edmonton, Alberta
T6G 2G5

Dear Mr. Kiffiak:

Re: Research Request - Conceptions of a Canadian Context for Science Education - Richard Mrazek

The above research request has been approved on a permissive basis following examination by our department.

Mr. Mrazek should now directly contact the principals of the schools listed on the attached page to obtain final approval and to make the arrangements necessary for conducting the study.

I would appreciate receiving a copy of the results of the study as soon as they are available.

Sincerely,

T.A. Blowers, Ph.D.
Director Instructional Resources
Research, Liaison

TAB/jmr

cc: Dr. H. Kass
Mr. R. Mrazek
Principals

COPIE DE QUALITEE INFERIEURE

Edmonton Catholic School District

EDUCATIONAL AND ADMINISTRATIVE CENTRE
TELEPHONE (403) 429-7631 — 9807 - 106 STREET, EDMONTON, ALBERTA T5K 1C2

1982 04 07

Mr. A. Kiffiak
Room 341
Education South
Faculty of Education
University of Alberta
T6G 2G5

Dear Mr. Kiffiak:

RE: Request made by Dr. H. Kass on behalf of Richard Mrazek: Conceptions of a Canadian Context for Science Education.

The above request has been approved by the Catholic School District.

Mr. Mervyn Lynch, Supervisor of Sciences, has approved the questionnaire to be used in the study.

Suggested schools to be approached are:

St. Francis of Assisi
St. Edmund
J.J. Bowlen
St. Mary
Archbishop MacDonald
St. Joseph
Austin O'Brien
St. Francis Xavier
Louis St. Laurent
Archbishop O'Leary

Results of the above mentioned study is requested by the Catholic School District.

Sincerely,

Annette Daigle
Test & Research Coordinator
Student Services

cc: Dr. D. MacDougall
Assistant Superintendent
Student Services

Mr. Richard Mrazek
Secondary Education
University of Alberta

Dr. H. Kass
Secondary Education
University of Alberta

EDMONTON R.C. SEPARATE SCHOOL DISTRICT NUMBER SEVEN

COPIE DE QUALITEE INFERIEURE

St. Albert Protestant Separate
School District No. 6

March 25, 1982

Mr. W. A. Kiffiak
Field Services
Faculty of Education
341 Education South
University of Alberta
EDMONTON, Alberta
T6G 2G5

Dear Mr. Kiffiak:

The Cooperative Activities Program request on behalf of RICHARD MRAZEK is approved, signed and returned herewith.

Yours truly,

for: E. M. Martin
Assistant Superintendent
Curriculum and Instruction

enclosure

60 Sir Winston Churchill Ave., St. Albert, Alberta, Canada T8N 0G4
PBX (403) 458-2060

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COOPERATIVE ACTIVITIES PROGRAM

1. **Nature of Activity** (Check One)

Student Teaching Internship ______ Demonstration/Experimentation ______

Special Practicum ______ Research X

2. **Organization to be Involved**

Edmonton Public School System X County of Strathcona ______

Edmonton Separate School System X St. Albert Protestant/Separate School System X

N.A.I.T. ______

3. **Requestor** (University staff member)

Name Dr. H. Kass Department Secondary Education

Telephone 432-5415 Position Professor Date March 15, 1982

Request made on behalf of Richard Mrazek
(Name)

Secondary Education, University of Alberta 432-2022
(Address) (Telephone)

4. Description of Activity - Include title, objectives, procedure, evaluation, techniques, etc.

Conceptions of a Canadian Context for Science Education

The purpose of this study is to determine conceptions of a Canadian context for science education held by prospective science teachers and practicing science teachers relative to conceptions proposed by the author in his Theoretical Perspective for 'A Canadian Context for Science Education'.

The instrument used is a questionnaire which asks the participants to rate their agreement/disagreement for inclusion of various elements in a Canadian Context for Science Education (see attached form). The responses will then be analyzed for viewpoints endorsed by various groups within the sample. The sample shall sist of science student teachers and their cooperating teachers.

All information regarding the identity of participants will be held in strictest confidence.

Biology Phase III Student teachers — Jr. High Cooperating Teacher
Biology Phase III Student teachers — Sr. High Cooperating Teacher

Physical Science Phase III Student teachers — Jr. High Cooperating Teacher
Physical Science Phase III Student teachers — Sr. High Cooperating Teacher